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MANGOLD FLY INCIDENCE ECONOMIC IMPORTANCE AND CONTROL

by R. A. DUNNING
Rothamsted Field Station, Dunholme, Lincs

IN England, mangold fly, *Pegomyia betae* Curtis, is a sporadic pest and at present causes little harm, but widespread attacks a few years ago led to research into its incidence, biology, host range, parasitism and control. The distribution of attacks on sugar beet vary from year to year but the most severe attacks usually occur in Yorkshire, Nottinghamshire, the West Midlands and coastal regions of East Anglia, especially on the lighter sandy soils in which pupation and fly emergence is simplified. Occasionally, as in 1955 (Dunning, 1956), the pest attacks in regions where it is not normally abundant and clearly various factors affect its distribution. Food and cover in the spring are probably important for the flies, because they are rarely prevalent in the open fen regions, even though the soil is light. White (1953), reviewing the 1946-50 N.A.A.S. surveys on beet and mangolds, considered that the most severe damage occurs in Wales and North England.

Field trials in 1956 and 1957 tested new insecticides and attempted to determine the levels of attack justifying control. Severe and early attacks, which can affect yield considerably, are uncommon in England and generally damage appears more serious than it really is.

ANNUAL LEVEL OF ATTACK

Few numerical data record the annual level of attack before 1947 in this country. M.A.F.F. Miscellaneous Publication No. 62 discusses the status of mangold fly over the years 1917-27, and indicates that the most severe attacks were in 1921-25. Roebuck (1936, 1939), considered that the fly populations varied less from year to year than did those of most other pests. He studied the third generation infestation in north Lincolnshire from 1925 to 1939 and found it most abundant in 1924, 1925, 1929 and local in 1930, 1932 and 1937. Only in 1929 and 1930 was the fly a pest, and even then a mild one.

In monthly reports of insect pests dating from 1917 to 1947, most attacks were recorded in 1923-30, 1940 and 1946-47, with 1947 as the peak year (information kindly supplied by the Plant Pathology Laboratory, Harpenden).

Since 1947 the annual level of attack has been recorded by monthly reports from the British Sugar Corporation, and on a more accurate quantitative basis since 1957 in the form of individual reports from each fieldman (about 140 reports per month). Each month the acreage "failed," and the average affected "severely" (likely to cause yield loss) or "moderately" (not likely to cause yield loss), or "slightly" (pest present in small numbers and obviously not causing any significant damage) were reported separately by each of the 18 factories and the southern area of the British Sugar Corporation. Only 102 acres failed because of mangold fly attacks in the years 1947-60 inclusive, and other causes may have contributed to these failures. The total "month-acres" affected for April-September each year have been converted to an index using a formula based on the author's opinion of the relative importance of the various categories of damage.

$$\text{Infestation Index} = \text{"Failed"} + \frac{\text{"Severe"}}{10} + \frac{\text{"Moderate"}}{100} + \frac{\text{"Slight"}}{1{,}000}$$

The resulting annual index is plotted in Fig. 1. As the method of reporting changed in detail between 1956 and 1957, the two periods are not strictly comparable but, after the heavy attacks of 1947, there was clearly a period of lower incidence, especially in 1950 and 1951, then a build-up to the extensive attacks of 1954 and 1955, followed by a further five years of low incidence.

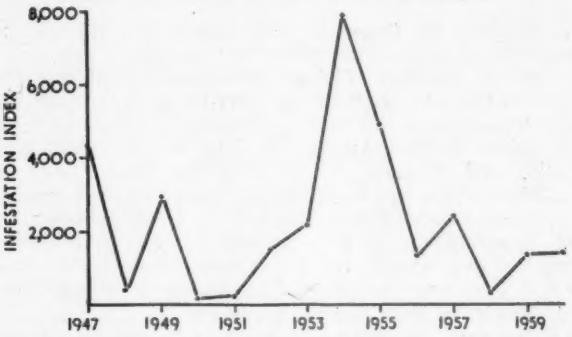

Fig. 1. Fluctuations in annual level of mangold fly attack on sugar beet in England, 1947-60.

Recent data on the total acreage sprayed annually to control mangold fly also indicates its relative importance each year (total beet acreage approximately 405,000 acres): 1955: 43,000; 1956: 27,000; 1957: 44,400; 1958: 4,600; 1959: 23,200; 1960: 8,200. Some of this spraying was undoubtedly encouraged by early aphid infestation in 1957, 1959 and 1960.

The general conclusion to be drawn from the published data and these more recent surveys is that mangold fly attacks fluctuate over relatively long periods. The increase or decline of the successive generations in one season can usually be explained largely by weather, but the long term fluctuations must result from other factors, one of which is parasitism. This was studied in detail in many individual fields in 1949 and 1950, and reached 96 per cent of the overwintering pupae in one. Apart from egg parasites and various predators, twelve larval or pupal parasites were recorded. In January 1949, 1950 and 1951 beet wash-water was sampled for pupae at five factories. The parasitism of these samples ranged from 47-90 per cent, averaging 59 in 1949, 73 in 1950 and 78 in 1951.

CONTROL TRIALS

Published work on control of mangold fly has advocated the use of chlorinated hydrocarbons, especially DDT or dieldrin in emulsion or miscible liquid formulation, where necessary for the control of serious attacks by the first generation (Dunning and Jones, 1950; Jones and Dunning, 1954). Parathion gave good control, but was considered too toxic for general use. Dunning (1956) suggested demeton-methyl for spraying late in the first-generation attack, when aphids may also be present.

Field trials in 1956 and 1957 compared insecticides on first generation attacks.

1956 Trial. (Ipswich, Suffolk). Plots: 6 rows (18 in wide) × 50 yd, with 7 treatments in 4 randomized blocks. Spraying: Land Rover-mounted sprayer at 20 g.p.a. Weather: Cool (average during trial period 54·5° F) with no rain until second day after spraying, and then only slight. The

trial was at the end of the first generation attack, when most larvae were large and there were no fresh eggs.

Table 1 gives the counts of larvae in leaf samples before spraying and on the second and fourth days after spraying. The numbers of larvae surviving treatment and remaining in the mines is the most practical measure of efficacy, as well as being the most accurately determined, and only these counts were analysed statistically.

The dead larvae per sample were difficult to count accurately, but Table 1 shows that the organo-phosphorous compounds killed more rapidly than the chlorinated hydrocarbons. These figures do not give a true measure of the effect of DDT, which greatly decreased the final numbers of living larvae. It is not clear whether the larvae that left the leaves, probably because of the insecticide, had been killed.

TABLE 1

Effect of Treatments in Trial at Ipswich, 1956

Treatment With oz. of Active Ingredient per acre	Numbers of Larvae per 40 Mined Leaves (Mean of 4 Plot-Samples)				
	June 5 Pre Spraying	2 Days After Spraying		4 Days After Spraying	
	Live	Live	Dead	Live	Dead
DDT 16 oz.	48·8	29·8	5	7·3	7
Dieldrin 6 oz.	39·5	3·8	13	0·3	23
Trichlorphon 6 oz.	44·5	8·5	45	3·5	50
Trichlorphon 3 oz.	41·5	11·0	28	3·5	49
FAC/20 6 oz.	43·3	9·8	30	2·8	66
Demeton-methyl 7 oz.	45·8	8·5	20	4·8	30
Control	40·8	44·4	5	29·4	4
S.E. per treatment mean	±2·98	±2·57		±1·58	
L.S.D. (p = 0·05)	N.S.	7·6		4·7	

On the second and fourth days after spraying all insecticides had significantly decreased the number of living larvae. On the second day, dieldrin, trichlorphon (both rates), FAC/20 (emulsifiable oil containing 20 per cent w/v N-monoisopropylamide of 00-diethyldithiophosphoryl-acetic acid plus solvent and emulsifier) and demeton-methyl were significantly better than DDT but differed little among themselves, although dieldrin appeared to be best. On the fourth day after spraying, dieldrin, FAC/20 and trichlorphon (both rates) were significantly better than DDT; demeton-methyl did not differ significantly from either group.

In a trial at Rothamsted Field Station, Dunholme, Lincoln in 1956, primarily designed to test the effect of mangold fly sprays on the subsequent incidence of virus yellows, the kill of larvae was assessed on May 31, six days after spraying, as follows (mean of 4 plots): DDT 65, trichlorphon 83, demeton-methyl 74, per cent.

1957 Trial. (W. Dereham, Norfolk) Plots: 5 rows (21 in wide) × 130 yd. with 8 treatments in 4 randomized-blocks. Spraying: Land Rover-mounted sprayer at 20 g.p.a. Weather: cool (average during trial period 51·1° F),

with no rain until second day after spraying, and then only slight. At the time of spraying on May 22 the plants had an average of 3·75 rough leaves with 2 unhatched eggs and 3 larvae per plant.

Table 2 gives the counts of larvae in leaf samples. In counting unhatched eggs errors were high, especially on the fourth and eighth day after spraying, and none of the treatments produced significant differences; the eighth day results suggested an ovicidal action by trichlorphon but the counts obtained have been omitted from Table 2.

TABLE 2

Effect of Treatments in Trial at W. Dereham, 1957

Treatment With oz. of Active Ingredient per acre	Numbers of Larvae per 60 Mined Leaves (Mean of 4 Plot-Samples)						
	Pre Spraying	2 Days After Spraying		4 Days After Spraying		8 Days After Spraying	
	Live	Live	Dead	Live	Dead	Live	Dead
DDT 13 oz.	101	26·5	32·0	10·0	77·8	20·3	108·5
Dieldrin 6 oz.	95	16·5	30·0	9·5	83·3	14·8	90·3
Trichlorphon 6 oz.	98	6·0	55·3	2·3	94·3	4·5	73·0
FAC/20 4 oz.	107	3·0	51·3	3·3	79·8	14·0	76·3
Malathion 15 oz.	89	8·8	40·8	34·5	54·5	59·8	28·3
Demeton-methyl 7 oz.	102	22·0	30·5	33·8	56·5	83·5	33·5
Phosdrin 5 oz.	110	5·8	46·3	14·8	72·0	43·5	56·3
Control	101	49·8	13·0	93·3	9·8	141·0	0·8
S.E. per treatment mean	±6·7	±3·8	±5·3	±5·6	±7·1	±6·9	±7·1
L.S.D. (p = 0·05)	N.S.	11·2	15·6	16·3	20·7	20·3	21·2

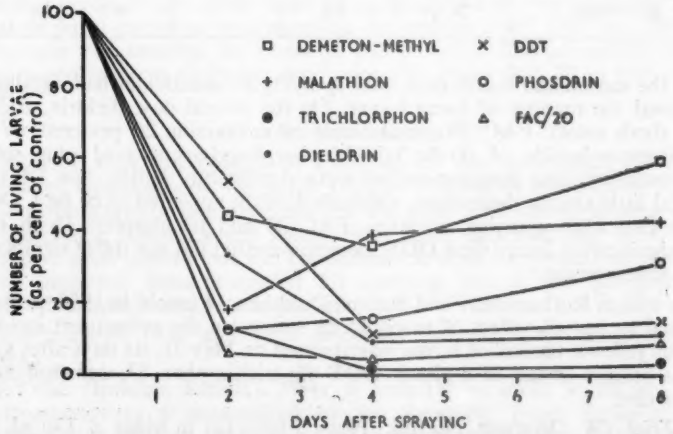

Fig. 2. Numbers of living larvae per treatment at intervals after spraying, expressed as a percentage of the control (W. Dereham, 1957).

The numbers of dead larvae per treatment on the second, fourth and eighth days after spraying differed considerably; trichlorphon and FAC/20 killed the most rapidly. As in the 1956 trial, counts of dead larvae, especially on the eighth day, were made inaccurate by fresh larval mining.

Fig. 2 shows the numbers of living larvae expressed as a percentage of the control population. FAC/20, trichlorphon, dieldrin and DDT, in decreasing order of speed of action, substantially decreased the numbers of living larvae. All showed the maximum kill four days after spraying, although this may have been earlier with trichlorphon and was almost certainly so with FAC/20. Phosdrin and malathion gave quite good initial kills, especially the former, but lacked persistence. This was expected with phosdrin, which is a transient insecticide, but not with malathion. Demeton-methyl gave a maximum kill of 64 per cent on the fourth day after spraying, but on the eighth day the number of living larvae per plot sample had risen considerably. Table 2 shows the statistical significance of these results.

DISCUSSION ON INSECTICIDES

The resurgence of virus yellows in recent years has emphasised that, where aphids and yellows are prevalent, any sprays used for first generation mangold fly attacks (especially when applied late) should also give some control of early aphids and must certainly not lead to any risk of increasing yellows. Spraying to control a second generation of mangold fly is justified only with a very severe infestation and an aphicide should then be used. Recent work, to be published elsewhere, tested many insecticides for control of aphids and yellows, and reference is made in the following discussion to the action of each insecticide upon aphids. A material to control heavy mangold fly infestations should rapidly kill 80 per cent or more of all larval stages when used as a low-volume spray and should be cheap and safe. Persistence and ovicidal action are useful, but not essential in practice.

The only insecticides common to all three trials were trichlorphon, DDT and demeton-methyl and their mean relative efficiency was 90, 77 and 74 per cent kill respectively. In other trials in 1957, trichlorphon gave even better results (Table 3). The kill given by DDT and demeton-methyl was probably adequate for all but the most severe first generation attacks; demeton-methyl was even effective against large larve in the 1956 trials at Ipswich. These three insecticides are the chief materials used commercially in recent years and field reports indicate the same relative order of efficiency as above.

Trichlorphon undoubtedly controls mangold fly well; it kills all stages rapidly and has some ovicidal action (Kolbe, 1958), but it does not control aphids.

DDT-oil emulsion at 12 oz active ingredient per acre (Jones and Dunning, 1954) gave very good results, but larger amounts gave poorer results in the trials described above. Durgeat, Missonier and Portier (1959), in listing suitable insecticides, dismissed DDT (with malathion and demeton) as insufficiently larvicidal, even with small larvae, but this is not so in England. Q. A. Geering (Fison's Pest Control) and J. H. Stapley (Plant Protection Ltd.) have kindly let me see the unpublished results of their trials; both found DDT gave very good results. DDT has been widely used for several years and given adequate control when the larvae were not too large; its slow kill is then not a serious disadvantage and it has good persistence. Information is extensive on the aphicidal properties of DDT (e.g. Broadbent, Burt and Heathcote, 1956) which when applied early to beet controls green aphids to a certain extent and can decrease virus yellows (paper in preparation). However, DDT must not be

used late in the season when black aphids are present, because it tends to increase the infestation, probably by killing predators (Dunning, 1956).

Demeton-methyl has given good results in a few trials, but usually kills only 60-70 per cent of the larvae. It is strongly aphicidal and is a satisfactory material to use when mangold fly and aphids are present and partial control of mangold fly is adequate (Dunning, 1956). When better control of mangold fly is necessary, trichlorphon should be added (Kolbe, 1958).

TABLE 3

Plant Size and Infestations before Spraying in British Sugar Corporation Yield Trials using Trichlorphon, 1957

Site, Factory, Soil type and Date Sprayed	Mean No. of Rough Leaves per Plant	Mean No. per Plant of Mangold Fly:		Kill *per cent*
		Eggs	Larvae	
Coningsby, Bardney; Sand, May 21	3·4	3·9	3·1	98
Grimsby, Brigg; Wold Chalk, May 21	2·7	2·9	2·4	95
West Row, Bury; Light Sand, May 23	4·2	0·0	0·9	100
Drayton, Cantley; Light, May 8	1·6	0·6	1·1	97
Felsted, Felsted; Heavy, May 28	4·8	0·1	0·2	84
*Grantham, Kelham; Sand, May 8	2·8	3·4	1·0	93
*Kettering, Peterborough; Loam, May 21	4·9	8·2	8·3	96
*Barlow, Selby; Sand, May 20	2·2	0·5	1·9	100
Truro, S. Area; Med. Loam, May 22	4·9	0·1	1·6	100

* Sites where yield assessment was made.

Phosdrin, at a relatively high rate per acre, killed larvae rapidly in the 1957 trials but its effect did not persist. It could be used for simultaneous control of both mangold fly and aphids but is not the best material for either pest alone.

Dieldrin in these and previous trials in England, including extensive trials by the National Agricultural Advisory Service, gave excellent control and the commercially recommended rate of 6 oz active ingredient per acre could be lowered. Stenvers (1956) recommended that dieldrin must be applied as soon as the first mines develop, but he used the low rate of only 2·4 oz a.i. per acre. Durgeat *et al.* recommended 5·7 oz a.i. per acre. It acts more rapidly than DDT, but it has slight or no aphicidal action.

FAC/20, which is not available commercially in the United Kingdom, gave good results in the two trials.

The results obtained with malathion in 1957 may be misleading. H. C. F. Newton *(in lit.)* reported an excellent and rapid kill of celery leaf-miner with this material at 15 oz a.i. per acre in one trial, far better than DDT, BHC and dieldrin used for comparison at recommended dosages. Malathion controls aphids well under ideal conditions, but it is not known whether it affects the incidence of yellows.

Parathion is occasionally used to control mangold fly, which it does rapidly and well, and can control aphids and yellows, but it is too toxic for general recommendation.

Endothion, recommended by Durgeat *et al.* for mangold fly control, controlled aphids and virus yellows well in 1959 trials.

Trials in 1958 by Messrs. Fison's Pest Control (Geering, Q. A., Bond, B. A. and Bryan, K. in an internal report) showed the efficiency of dimethoate against mangold fly larvae at one-quarter the dosage needed for aphicidal effect on beet. A few reports of field usage in 1959 support this contention. It is the cheapest of any treatment.

Recommended Insecticides.

a) For mangold fly control alone:

DDT (15 oz a.i./acre) kills slowly but its action persists. Is less effective than others when attacks are heavy or larvae are large.

Dieldrin (5-6 oz a.i./acre) for any level of attack or stage of larva.

Trichlorphon (6 oz a.i./acre) for any level of attack or stage of larva, and kills rapidly.

Parathion (3 oz a.i./acre) for any level of attack or stage of larva and kills rapidly. Very toxic, and protective clothing must be worn when spraying.

Dimethoate (1·2 oz a.i./acre) for any level of attack or stage of larva, and kills rapidly.

b) For simultaneous mangold fly and aphid control:

Trichlorphon (4 oz a.i./acre) + demeton-methyl (7 oz a.i./acre) controls both pests excellently and virus yellows well.

Parathion (3 oz a.i./acre), see above. Fair control of aphids and virus yellows.

Dimethoate (4·8 oz a.i./acre) controls mangold fly excellently and green aphids and virus yellows well. (Increased dosage is necessary to control *A. fabae).*

Less effective materials are Phosdrin (4 oz a.i./acre) and malathion (15 oz a.i./acre). DDT should not be used when *A. fabae* is present. Dieldrin or trichlorphon should not be used alone when any aphids are present in areas where virus yellows is prevalent until their effects can be tested more fully.

All insecticides are best in oil emulsion or miscible liquid formulations with wetters, and increasing the amount of water per acre tends to give better control. " Band-spraying " is suitable for sugar beet in May and early June if done carefully, and it lowers the cost of insecticide considerably.

ECONOMIC ASPECTS OF CONTROL

The use of insecticides able to control mangold fly has developed only in the last decade and data on the level of infestation justifying spraying are few. Experimental results on yield loss available were reviewed by Kolbe (1958), who concluded that losses of at least 10 per cent occur in moderate to severe infestations. Varis (1959) obtained a 20-25 per cent increase in sugar yield when a severe mangold fly attack was controlled in southern Finland in 1958.

Apart from yield trials in this country (Jones and Dunning, 1954), one approach to the problem was the artificial defoliation of beet by cutting off leaves at the 4- and 8-leaf stages (Jones, Dunning and Humphries, 1955), but this only approximately imitated the defoliation caused by mangold fly. It showed that at least 50 per cent defoliation is needed before root yield is affected. A further theoretical approach is to relate the actual leaf area consumed per larva (" up to 10 sq. cm ": Kolbe, 1958) to the average leaf area per plant at different stages (1 sq. cm in early cotyledon stage increasing to 60 sq. cm in expanded 4-leaf stage: Durgeat *et al.* 1959). Neither method takes account of any possible toxic effect from the mining larvae.

Nine trials done with the co-operation of the British Sugar Corporation in 1957 assessed yield at different levels of infestation on different soil types. Each trial consisted of alternate, randomized sprayed and unsprayed strips, replicated six times. Trichlorphon was used in all trials at the rate of 6·4 oz a.i. in 20 gallons of water per acre, a rate slightly higher than the normal field recommendation to ensure the maximum kill. Table 3 shows the number of leaves and level of attack per plant before spraying, and the kill of larvae one week after spraying.

The level of attack in the Bury St. Edmunds, Felsted and southern area trials was too low to justify yield determinations. At Peterborough, Selby and Kelham sprayed and unsprayed plots gave similar yields, although growth had appeared better on the sprayed plots shortly after treatment. Yields were not determined at the remaining three sites.

In each factory area the trial site selected was that with the most eggs and/or larvae per plant that could be found at the time, but the heaviest infestations were only moderate attacks and the results help to confirm that only severe attacks are likely to decrease yield. Fig. 3 shows the levels of infestation (the total of fresh eggs and living larvae per plant at the time of spraying) for six yield trials in England plotted against the size of the plant (the number of rough leaves, excluding cotyledons). Spraying significantly increased yield in only one trial. The suggested probable level of attack, above which loss of yield is likely to occur, approximates to a level of infestation equal to the square of the number of rough leaves, and this serves as a convenient guide for advice about spraying. However, the damage caused in any crop will be

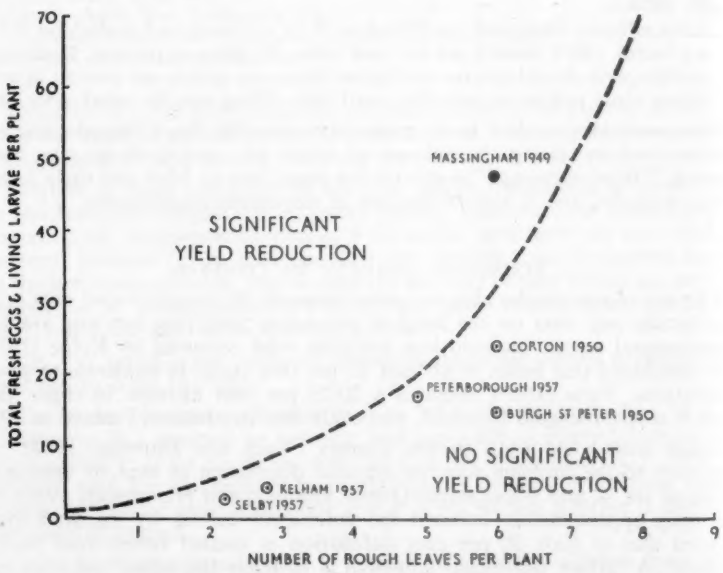

Fig. 3. Probable level of attack above which significant loss of yield occurs, based largely on yield trials in 1949, 1950 and 1957 (The extent of defoliation was estimated in three trials: at Massingham, 70 per cent; at Corton, 50; and at Burgh St. Peter, 30 per cent).

affected by many factors, especially the proportion of larvae in the infestation. Probably no crop past the eight-leaf stage is worth spraying against mangold fly alone, a conclusion that has also been reached in Belgium (M. Simon, *in lit.*).

The circumstances that lead to severe attacks—poor backward growth with heavy infestation per plant—are not common in England. They occurred at Massingham in 1949, when singling just preceded the bulk of egg-laying on the plants and infestation per plant was very high, causing 70 per cent defoliation, but the sprayed plots yielded only about 5 per cent more than the unsprayed (Fig. 3). However, the cost of spraying is low and equals about ¼-ton of beet, so can be justified as an insurance if the pest threatens to cause damage. There is more justification for spraying with aphicidal materials, especially in areas where virus yellows is important.

SUMMARY

Attacks by mangold fly are most frequent in coastal regions and in the North and West, and occurred especially in 1947 and 1954-5. The results of comparative tests of insecticides are given and recommended insecticides listed; the use of materials that are also aphicidal is advised when aphids are present, especially in areas where virus yellows is important. Results from yield trials suggest that only in severe attacks on backward beet is control of mangold fly alone economically justifiable in England.

I am indebted to Miss Marie Wolfe for assistance; to the firms who supplied the insecticides; to the farmers who co-operated so readily; and to the British Sugar Corporation for provision of data and their help in field trials.

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EFFECT OF WINTER SPRAYING ON ROTTING OF STORED APPLES BY *GLOEOSPORIUM* SPP

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METHODS previously used in this country to reduce losses in stored apples caused by *Gloeosporium* spp. include pre-harvest fungicidal sprays (Marsh, Montgomery and Edney, 1957; Moore and Edney, 1959) and the use of dips and volatile fungicides after harvest (Anon, 1958; Fawcett, Spencer and Wain 1958). None of these treatments has provided a complete answer to the problem. Hamer (1958) reported a reduction in rotting of fruit from 80 to 25 per cent following the removal in three successive years of all obvious wood infections due to *Gloeosporium*. Byrde, Crowdy and Roach (1952) established that spore production from cankers caused by *Nectria galligena* on the varieties Lord Lambourne and Laxton's Superb could be reduced by spraying during the winter, using materials previously shown to have eradicant properties. Following more recent work at Long Ashton on wood infections of Cox's Orange Pippin by *G. perennans* (Corke, 1956), the possibility of reducing sporulation from these infections by fungicides was demonstrated (Sharples and Somers, 1959).

The trials described in the present paper were laid down to assess the effect of sprays, applied during the dormant season, on the incidence of fruit rotting during the subsequent storage season. An account of a series of similar trials carried out in New Zealand has recently been published by Brook (1959).

Cox's Orange Pippin trees on M I and Seedling Crab rootstocks on a commercial plantation in West Sussex were used for the trials, which were randomized in single tree plots. In Trials 1 and 2 each treatment was replicated 12 times, and in Trial 3, 10 times. A proprietary phenyl mercury compound was used for all mercury treatments at 0·1 per cent mercury. The same trees were used for Trials 1 and 2, and thus one third of the trees in Trial 2 received a mercury spray for the second year in succession. The treatments and dates of their application were as set out in Tables 1, 2 and 3. Each trial included unsprayed controls.

Sprays were applied with a hand lance, using a nozzle with a 5/64" disc orifice supplied from a trailer hydraulic machine giving 300 lb/sq. in. pressure; to spray each tree to run off required approximately 5 gallons of spray (approximately 275 gallons per acre). The fruit was picked on September 19, 1957 and on September 16 and 17, 1958. Random samples of 100 sound fruits were taken from each tree and sub-divided into four samples of 25 which were stored at 38° F. At each assessment, one sub-sample per tree was removed from storage and the number of apples infected with *Gloeosporium* recorded.

The dates of assessment were as shown in the Tables of results. No identification of the species causing each rot was made in Trials 1 and 2, but in Trial 3 this indentification was carried out. For analysis, the percentages of infected apples were transformed to angular values (maximum 90) and the significant differences ($p=0.05$) given in the Tables apply to these values. The percentages given were obtained by de-transformation of the angular values.

TABLE 1

Percentages of Infected Apples in Trial 1, 1957-58

Treatment	December 5 1957		December 17 1957		January 8 1958		February 5 1958	
	Per cent	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*
5 per cent tar oil on 21.ii.57	6·5	14·8	5·8	14·0	13·8	21·8	20·1	26·7
0·1 per cent mercury on 21.ii.57	3·5	10·8	6·3	14·5	5·3	13·3	8·8	17·2
Control	7·1	15·4	13·9	21·9	16·8	24·2	23·0	28·7
Significant Difference ($p = 0.05$)		N.S.		5·2		6·5		5·7

In Trial 1 the use of mercury in February resulted in a significant reduction in rotting of the fruit at all times of inspection during storage with the exception of the first date, when insufficient rotting had developed. Tar oil had little effect except at the second inspection.

TABLE 2

Percentages of Infected Apples in Trial 2, 1958-59

Treatment	November 6 1958		December 2 1958		December 22 1958		January 20 1959	
	Per cent	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*
5 per cent tar oil on 21.ii.57 0·1 per cent mercury on 21.ii.58	7·3	15·7	13·8	21·8	19·7	26·3	22·5	28·3
0·1 per cent mercury on 21.ii.57 0·1 per cent mercury on 21.ii.58	5·6	13·7	9·9	18·3	13·5	21·5	17·4	24·7
Control	16·6	24·0	31·7	34·2	30·1	33·3	39·4	38·9
Significant Difference ($p = 0.05$)		7·8		6·6		5·2		6·6

In Trial 2 the mercury treatment gave a significant reduction of infection at all inspections. Fruit from those trees receiving mercury for the second successive year did not suffer significantly less wastage than from those trees which received tar oil in 1957.

In Trial 3, while all treatments gave control at the second inspection, only the November and the November + February treatments gave control at the third inspection. At the fourth inspection, control was obtained only where the two sprays (November + February) had been applied.

TABLE 3

Percentages of Infected Apples in Trial 3, 1958-59

Treatment	November 6 1958		December 2 1958		December 22 1958		January 20 1959	
	Per cent	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*	*Per cent*	*Angle*
0·1 per cent mercury on 28.xi.57	5·2	13·2	12·1	20·4	14·9	22·7	26·4	30·9
0·1 per cent mercury on 21.ii.58	1·6	7·2	10·9	19·2	18·1	25·2	27·1	31·4
0·1 per cent mercury on 28.xi.57 and 0·1 per cent mercury on 21.ii.58	2·5	9·2	9·6	18·0	13·4	21·4	16·2	23·8
Control	7·0	15·3	22·4	28·2	24·8	29·8	35·6	36·6
Significant Difference (p = 0·05)		N.S.		6·6		6·0		7·4

DISCUSSION

Whereas in Trials 1 and 2 a single February treatment with mercury gave control throughout the period of storage, in Trial 3 it was the least successful treatment and had no significant effect after the second inspection. The control obtained in Trial 1 can perhaps be attributed, at least in part, to the fact that the level of rotting was generally considerably lower in 1957 than in 1958. Comparing Trials 2 and 3 which were carried out in the same season, it is evident that both the Febuary treatments with mercury were more effective in Trial 2 than in Trial 3, although the level of rotting in the controls in both trials was about the same. A possible explanation of these results is that in Trial 2, the reduction in rotting was due to the lower level of inoculum present on the trees sprayed in the previous year. Although the level of inoculum was apparently not reduced to the same extent by the tar oil as by the mercury spray in 1957, it appears that the effect was sufficient to enable the mercury applied for the first time in 1958 to give a reduction in the amount of rotting approaching that obtained with applications of mercury in two successive years. Further work is now in progress on the effect of applying mercury in successive years.

The total rainfall between May 1 and harvest in 1957 was 10·01 inches compared with 15·46 inches during the corresponding period in 1958. The higher rainfall during the summer of 1958 is reflected in the higher level of rotting in Trials 2 and 3. It is generally considered by growers that storage of apples becomes uneconomic if wastage exceeds 10 per cent. Thus, although a significant reduction in the amount of wastage was achieved, the degree of control obtained is still inadequate as judged by this standard. Since it is impossible to predict the weather during the growing season, the severity of *Gloeosporium* attack cannot be anticipated. Our results suggest that control measures which are satisfactory in a dry season may be less effective in a wet season; it is by the reduction in the level of rotting after a wet season when the storage quality of the fruit is poor, that the success of a control method must be judged.

Improved control could be achieved by a more effective treatment during the dormant season, or by the use of suitable additional sprays during the growing season, should conditions warrant their use. The value of this latter method has been demonstrated by Brook (1959). Whilst the relatively high concentration of 0·1 per cent mercury causes no phytotoxic effects when

applied during the dormant season, it is potentially toxic to the person applying the spray, and protective clothing must be worn during application. Furthermore, it is considered that this concentration may be uneconomic, and accordingly, the ability of lower concentrations to control this disease is being assessed.

SUMMARY

Sprays of a proprietary phenyl mercury compound were applied to Cox's Orange Pippin trees during the winters of 1957-58 and 1958-59. In the first season, a single spray applied in February gave a significant degree of control of rotting of stored fruit caused by *Gloeosporium* spp. In 1958-59, different results were obtained in two separate trials of this treatment and in one instance control was obtained only where the February spray was augmented by a spray applied in November.

The authors wish to thank Mr. W. Fowle, Costrong Farm, Kirdford, for providing the plots of trees and for his co-operation throughout these experiments. Mr. P. Roberts, Statistical Section, Jealott's Hill Research Station was responsible for the layout of the trial areas and the analysis of the results. Messrs. A. D. S. Duff and E. Hainsworth, formerly of Fernhurst Research Station, were responsible for a major part of the initial contribution made by Plant Protection Limited, and Mrs. K. I. Partridge, formerly of Ditton Laboratory, assisted in the recording of Trials 2 and 3.

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BEAN APHID CONTROL ON FIELD BEANS IN RELATION TO THE FLOWERING PERIOD AND TO HONEY BEE POISONING

by M. J. WAY *

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INSECTICIDES applied to flowering crops are likely to harm honey bees. This was once a serious problem in orchards, but was largely solved when it was found that fruit tree pests could be controlled effectively by insecticides applied before or after flowering. Recently, insecticides have been used increasingly on arable crops and have killed honey bees, notably when used to control pollen beetles, *Meligethes* spp., on flowering brassica crops and the bean aphid, *Aphis fabae* Scop., on flowering field beans, *Vicia faba* L. (Anon, 1958-60; Ward and Needham, 1959; Needham and Solly, 1960).

Unfortunately, demeton-methyl, dimethoate and Phosdrin, the systemic insecticides mostly used against aphids, may poison bees, at least those working the crop at the time of spraying. Aphicides less poisonous to bees have disadvantages. For example, schradan is less effective and more expensive than the other aphicides, demeton has been replaced in this country by demeton-methyl, and nicotine is unreliable. Contact insecticides seem relatively ineffective against bean aphid (Way, Bardner, Van Baer and Aitkenhead, 1958) and some are very poisonous to bees, for example gamma-BHC, dieldrin and parathion (Jones and Connell, 1954; Beran and Neururer, 1955; Wiese, 1957-8; Anderson and Atkins, 1958). Systemic insecticides applied to the soil, or as seed dressings, would probably do less harm than foliage sprays to bees though there is greater danger that the insecticide may get into the nectar. However, soil or seed application seems impracticable at present. The possibility remains that aphicide sprays can be applied before or after the bean crop flowers.

METHODS

Records were made on 0·0013 acre garden plots in the year 1953, on 0·036 acre field plots in 1954 and on 0·019 acre field plots in 1955. Autumn and spring tick varieties of field bean were drilled in randomized blocks of replicated plots, eight plots for each sowing date, of which four were untreated and four sprayer with demeton or demeton-methyl to control bean aphid. In 1953, 0·05 per cent w/v demeton in water was sprayed to run-off with a knapsack sprayer. In 1954-55 a tractor-mounted field sprayer was used to apply 22 oz demeton in 140 gal of water per acre in 1954, and 6 oz demeton-methyl in 60 gal of water per acre in 1955. Other details are given in Table 1.

The numbers of bean aphids were estimated at about weekly intervals by categorising the aphid populations on 40 (year 1953) or 400 (years 1954-5) stems at random in each treatment (Banks, 1954). The mean number of aphids in a category was obtained by removing and counting the aphids on at least seven infested stems in that category. The means of the log $n + 1$ aphids per stem in each treatment were calculated from these data (Way, 1961).

* Now at Imperial College Field Station, Silwood Park, Sunninghill, Ascot, Berks.

Migrant alatae were assessed from weekly catches on sticky traps (Broadbent, Doncaster, Hull and Watson, 1948) set 3-4 ft high among the plots. Twenty traps were used in 1954 and seven in 1955.

Flowers were counted on 9-12 stems taken at random in each treatment; fresh flower trusses were labelled and newly opened flowers were counted at one or two day intervals.

TABLE 1

Spacing of Plants; Dates of Sowing and Spraying

Year	Autumn Sown Beans			Spring Sown Beans		
	Row Spacing in.	Sowing Date	No. of Plants/a 1000's	Sowing Date	No. of Plants/a 1000's	Dates of Spraying
1952-3	24	Nov. 7	90	Feb. 26	90	June 19
				April 11		July 3
1953-4	22	Oct. 20	76	March 12	206	June 4
						June 21
1955	22	—	—	March 19		
				April 25	190	June 23
				May 13		July 22*

* May sowing only.

TIMING OF SPRAY APPLICATIONS

One spray with a suitable systemic insecticide, given when the primary migration of the aphids from the overwintering host is almost complete, will protect an autumn-sown or early spring-sown bean crop from damage by bean aphid (Way, 1955; Way *et al.* 1958). The aphid will already have damaged the crop if spraying is delayed until the infestation becomes obvious. Such delay also makes control less efficient because the crop is taller and the aphids are no longer confined to the heads of the plants where they are easily reached by insecticides.

The time when the primary migration is complete, and hence the correct time for applying the insecticide, depends on the season (Way, 1961) and on the type of infestation on the winter host—*Euonymus europaeus* (Way and Banks, 1961). At Rothamsted between the years 1952 and 1959 the chosen date for spraying varied between June 12-23, except in 1959 when it was June 2.

Figs. 1-3 show results of experiments done in 1953-55 when correctly timed insecticide treatments were applied on June 19, June 21 and June 23. Treatments were also applied relatively early in 1954, to assess persistence, and late in 1953 and 1955 either to coincide with the time when some farmers might consider treatment was necessary (year 1953) or to control aphids on late-sown plots (year 1955).

RESULTS OF FIELD TRIALS

Experiments in 1953. Infestations of field crops by bean aphid were relatively small in 1953, smaller than on the experimental garden plots where numbers reached a peak of about 32 aphids per stem on the autumn-sown plots, 250 on the February sowings and 380 on April sown plots (Fig. 1a). Fig. 1b shows that the recommended spraying date (June 19) coincided with the end of flowering of the autumn-sown crop, the peak of flowering of the February-sown crop and

the beginning of flowering of the April-sown crop. Some farmers would have delayed treatment until the end of June or early July when infestations became obvious. The spraying on July 3 therefore corresponded to some field practice. By this time the February-sown crop had completed flowering but the April-sown crop was in full bloom. Spraying, correctly timed to control bean aphid, would therefore have endangered bees working a February-sown crop whereas late spraying would have endangered bees on the April-sown crop. It should be noted that the unsprayed and sprayed crops flowered at the same time, although aphid infestations on the unsprayed plants decreased the numbers of flowers produced by late-sown crops (Figs. 1b, 3d).

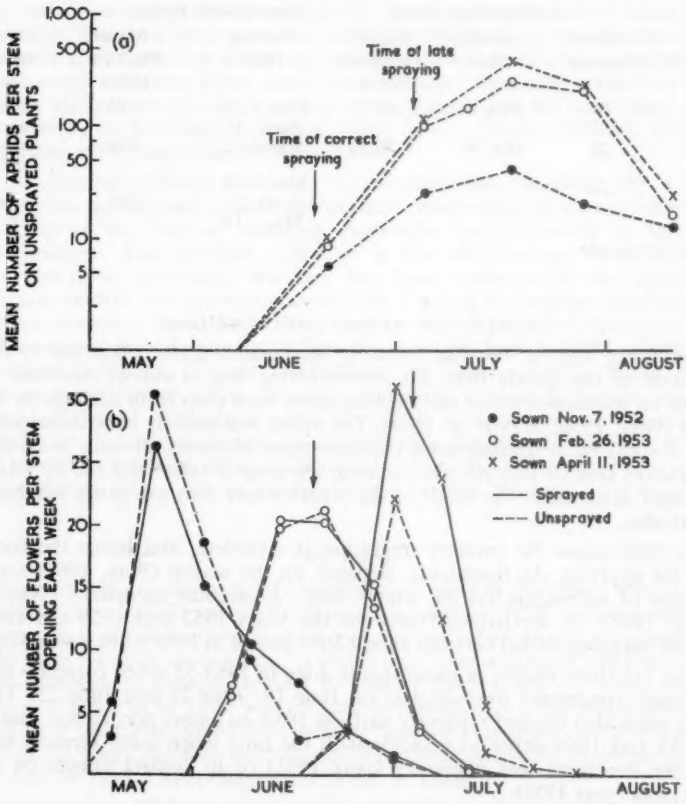

Fig. 1. Results of experiments in 1953.

Experiments in 1954. Many of the plants sown in October 1953 were killed or stunted by the cold winter. Such a crop would sometimes be ploughed in and redrilled. The flowering period was delayed and prolonged (Fig. 2c), the rather ill-defined peak of flowering corresponding with that of a February-sown crop. Soil conditions were unsuitable for a February drilling so a crop was sown in March.

1954 was a year of typical heavy bean aphid infestation with a large primary migration of alatae as indicated by sticky trap catches (Fig. 2a). Many flowers were open on the autumn-sown crop when the correctly timed demeton spraying was done on June 21 (Fig. 2b, c). A February-drilled crop would have been in full bloom at this time whereas Fig. 2c shows that the March sowing had not begun flowering.

Bees working a February-sown crop should be unharmed if the insecticide could be applied early in June; a persistent systemic insecticide would be needed to keep the growing crop from being infested by bean aphid during the next 2-3 weeks. Fig. 2b indicates, however, that demeton applied on June 4 at over five times the recommended rate lacked the necessary persistence.

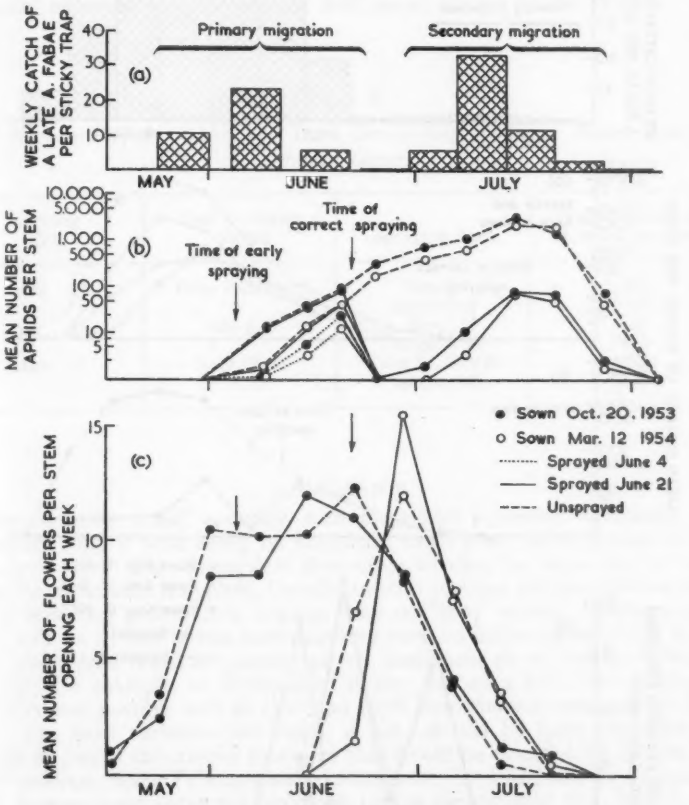

Fig. 2. Results of experiments in 1954.

Experiments in 1955. In 1955 initial infestations by bean aphid were smaller than in the year 1953, but fine weather in June, July and August benefited the aphids. Big populations developed on the April and May sowings in July from crawling apterae and from many secondary migrant alatae produced on various

summer hosts (Fig. 3a). Details of the structure and development of the different aphid populations are given elsewhere (Way, 1961). Briefly, the March-sown crop was unattractive to the secondary migrants and Table 1 and Fig. 3b show that aphids remained few on both sprayed and unsprayed plots. The peak populations of 85-100 aphids per stem were restricted to the non-flowering tips of the mature stems and were probably harmless to the crop. Thus the spraying done on June 23, correctly timed for the completion of

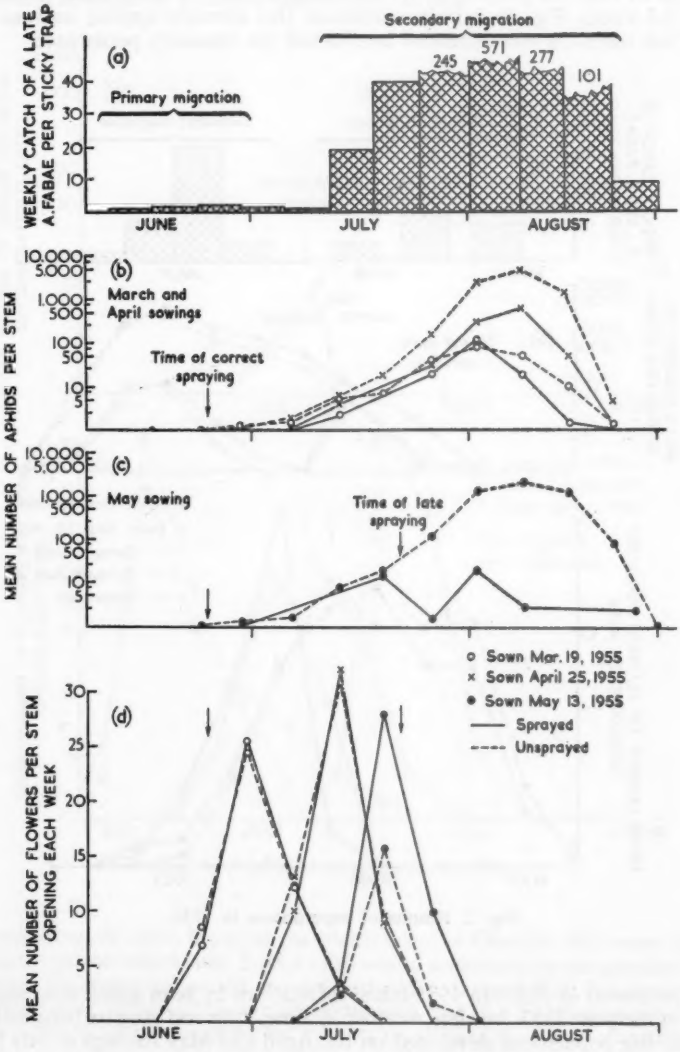

Fig. 3. Results of experiments in 1955.

primary migration, was not justified economically. This spraying was also unnecessary on the May-sown crop because the plants were just above the ground at the time of primary migration and were not infested by the primary migrants. In contrast, the correctly timed insecticide treatment decreased the peak aphid numbers on the April-sown crop from 3,470 to 620 because it killed the few primary migrants from which very many crawling apterae colonised the plants, which remained immature, and hence attractive, until about mid-July. The April and May sowings also remained attractive to secondary migrant alatae, so a second spraying was needed. This was given on July 22 to the May sowings only (Table 2, Fig. 3c). Fig. 3d shows that the first spraying on June 23, timed to kill the initial infestations, was done before either the March, April or May sown crops were flowering. The second spraying was done when the April sowing had almost completed flowering and the May sowing was in full flower. It should be noted that, in practice, field beans are not drilled in May.

TABLE 2

Peak Numbers of A. fabae *per Stem Developing on Field Beans sown at different Dates.*

Sowing date	Peak flowering period	Spraying dates	Peak mean no. of *A. fabae* per stem
Mar. 19	June 26–July 5	June 23	100
		unsprayed	85
Apr. 25	July 8–16	June 23	620
		unsprayed	3470
May 13	July 17–25	June 23, July 22	25
		unsprayed	2820

DISCUSSION

One correctly timed spraying with a suitable systemic insecticide will effectively control bean aphid on field bean crops sown before about the beginning of April. The sowing date determines whether the beans are in flower when the insecticide is applied. Usually autumn sowings will have almost completed flowering and March sowings may not have started. February-sown crops will be in full bloom and therefore very attractive to bees. On heavy land, where field beans are usually grown, conditions do not favour February drillings; for example, at Rothamsted during the years 1951-1960 drilling in February was possible only in 1953 and 1959. Sometimes a crop sown in February, like most autumn-sown crops, is not infested by bean aphid heavily enough to justify the control measures that would be essential for March and April sowings. Some February-sown crops were, however, heavily infested in 1959, as were some autumn-sown crops, and as the spraying date, June 2, was exceptionally early, some autumn-sown beans were flowering when treated. These exceptional conditions, together with unusually favourable weather for bee foraging, partly accounted for the many instances of harm to bees by aphicides in 1959 (Anon, 1960). However, the main recurring danger to bees visiting field bean crops seems to be from the unnecessarily late spraying of crops sown in March or April though a few bees may always be killed when visiting extra-floral nectaries, which function before the crop flowers.

In some years (e.g. 1955) an April-sown crop may become infested by secondary migrants of bean aphid and an aphicide may need to be applied in late July: bees should not be endangered by then, because flowering would be almost complete.

It is still most desirable that systemic insecticides should be developed which are as good as present-day chemicals against aphids but are much less harmful to bees and to other beneficial insects.

SUMMARY

Insecticides applied at the best time for controlling bean aphid are especially dangerous to bees on February-sown crops, because these are likely to be in full bloom when they need spraying. Crops sown at other times will usually have flowered or not yet flowered, though some bees may be visiting them for extra-floral nectar.

Most spring bean crops are sown in March or April and the main danger to bees seems to be from the unnecessarily late spraying of such crops.

I thank Dr. C. Potter for encouragement and advice and Mr. R. Goodchild for valuable assistance.

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SCABBED WOOD ON BRAMLEY'S SEEDLING (see p. 39)

Apple scab pustules on leaders *(a)* from 20-year-old unsprayed tree at Harpenden, August 1960; *(b)* from 10-year-old sprayed tree at Elmsted, Kent, September 1960; *(c)* healthy leader from Elmsted for comparison. (× 3½)

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PLATE I

SPORULATION OF BLIGHT ON POTATO TUBERS (see p. 40)

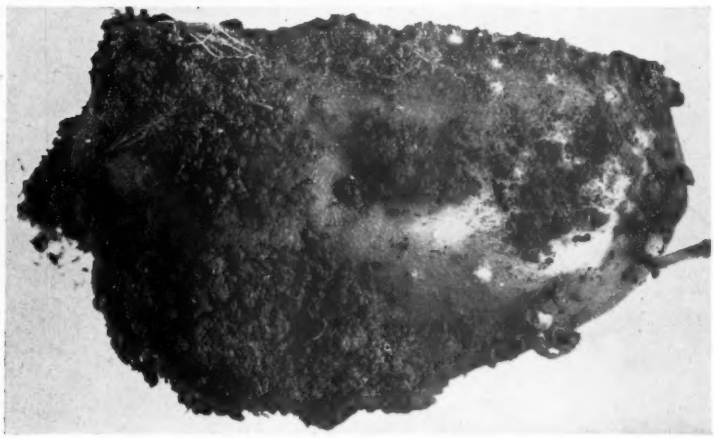
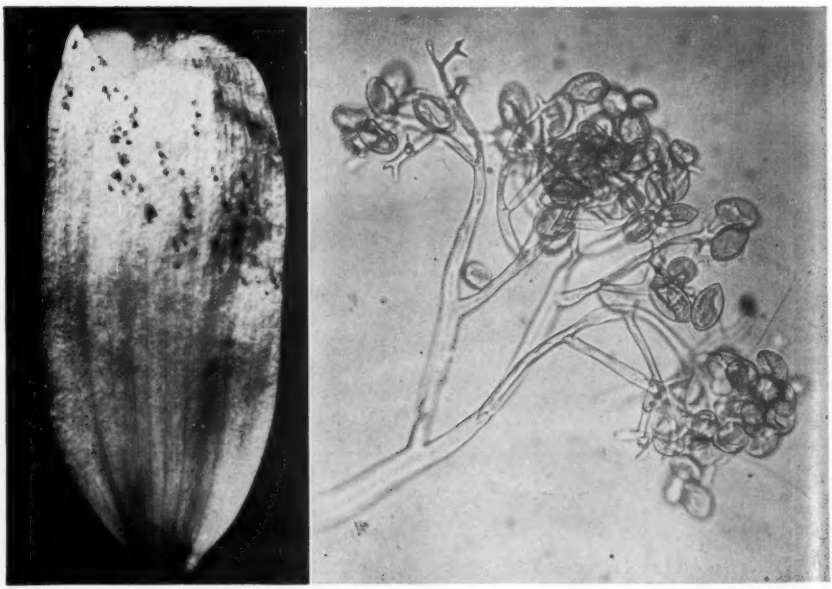


Photo: Rothamsted Experimental Station

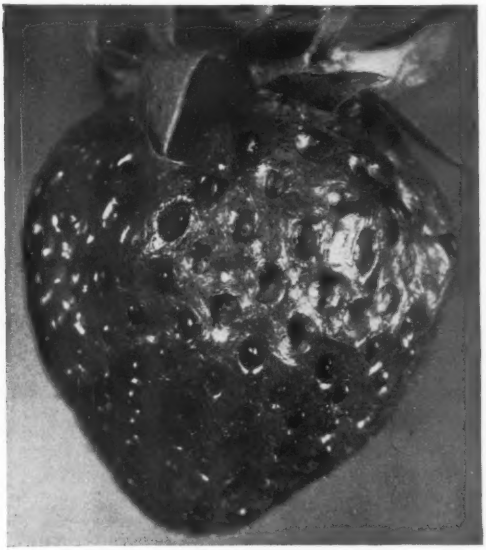
1. ***Phytophthora infestans*** sporing in tufts from the lenticels of a blighted tuber of Ulster Ensign as dug from within the ridges on August 15, 1960

DOWNY MILDEW OF CHRYSANTHEMUM (see p. 40)



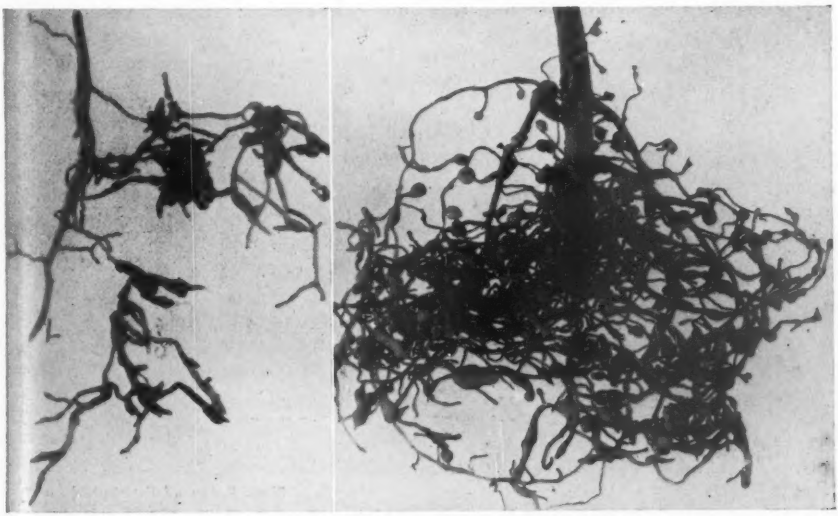
2. ***Left:*** Pin-head growths of *Peronospora radii* on outer floret (× 4½); ***Right:*** Conidiophores and conidia from one of the pin-heads (× 250).

LINNET DAMAGE TO STRAWBERRY (see p. 41)



1. Showing removal of seeds without laceration of fruit surface.

ROOT-KNOT EELWORM ON NURSERY PLANTS (see p. 41)



2. Galls caused by *Meloidogyne hapla* on roots. *Left:* of a *Berberis* hybrid; *Right:* of *Viburnum cassinoides*.

Photo: Rothamsted Experimental Station

Damage to the base of a cucumber plant by the glasshouse millepede, *Oxidus gracilis*.

CONTROL OF THE GLASSHOUSE MILLEPEDE

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and E. GUNN
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Oxidus gracilis (C. L. Koch) is a tropical species of millepede which is common in glasshouses in the British Isles. Although it has not been previously recorded from the south-west of England in the literature, it is quite common in glasshouses in this area. In one large nursery in Somerset serious damage to the cucumber crops has been caused by this pest over the past four years, which made it an urgent problem to find a satisfactory method of control.

On the experimental site cucumbers were grown regularly, and each year, soon after the cucumber beds were laid out, infestations of the millepede began to build up so that within a period of two months populations of the order of 250 per sq. ft. of bed had been attained. The life cycle of *O. gracilis* is believed to take more than five months from egg to mature adult, but since each female laid up to 300 eggs, and the early stadia were passed through quickly, multiplication was very rapid. Furthermore, only chemical methods of sterilization were used between crops, and it was obvious that a very considerable number of adult millepedes survived this period in cracks and crevices and under boards and pipes. It was probable that there was very little reinfestation from outdoors since the millepedes cannot survive freezing (Causey, 1953).

Although after two months most instars of the millepede could be found it was noted that the younger stages did not move about on the beds appreciably, and nearly all specimens trapped under boards laid on the paths were adults. Little activity occurred during the day, most of the feeding being at night.

Some doubt as to the pest status of this animal has been expressed in the literature, but there appeared to be no question that in this infestation considerable primary damage regularly occurred. Damage to the cucumber plants took the form of destruction of the soft tissue at the base of the stem, and in some cases this damage was so extensive that only the woody tissue remained (Plate IV).

FIELD TRIAL

The effectiveness of a range of insecticides was tested in the infested glasshouse. DDT was not used since it is phytotoxic to cucumbers. Treatments were applied as drenches to replicated plots which consisted of both sides of 8-ft runs of cucumber beds. Four gallons of diluted insecticide were evenly watered on to each plot from a two gallon watering can at dosage rates given in Table 1. Mortality counts were made at frequent intervals after treatment in order to estimate the relative persistence of the different materials. The estimates of mortality were made with a 6 in square frame, which was placed on the bed so that the numbers of live and dead millepedes found inside could be counted. A number of counts were made on each bed at each sampling date, with each sample taken on a previously undisturbed area of bed. The results which are summarized in Fig. 1 are based on the percentage mortalities, while the corresponding figures given in Table 2 show the actual mortality of millepedes due to the different treatments.

TABLE 1

Materials and Dosages

Materials	*Formulation*	*Dosage Rate*
Diazinon	20 per cent emulsion	1 fl. oz/10 gal
Lindane	10 per cent miscible	2 fl. oz/10 gal
Parathion	20 per cent emulsion	1 fl. oz/10 gal
Dieldrin	15 per cent emulsion	5 fl. oz/10 gal
Phosdrin*	99 per cent miscible	6 fl. oz/10 gal
Nicotine	98 per cent concentrate	1 fl. oz/10 gal
DDT†	15 per cent emulsion	10 fl. oz/10 gal
Aldrin†	1½ per cent dust	8 oz/8 ft bed
Naphthalene		16 oz/8 ft bed

† used only in laboratory experiments.

* used only in field experiments.

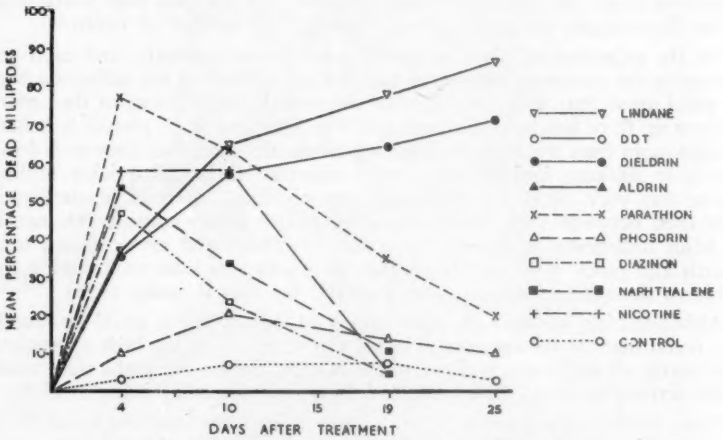

Fig. 1. Millepede mortality in the field trial.

LABORATORY EXPERIMENT

The large numbers of millepedes available from the field site enabled results to be confirmed in the laboratory. Tests were made in 5-in diam. pots half filled with soil. Solutions of insecticides were watered on to the soil at a rate of 3 fl. oz per pot, calculated to correspond with the rates that had been used in the field experiment in the amount applied per surface area. Each treatment was replicated three times. The soil was allowed to dry and then 30 adult millepedes were placed into each pot and covered with polythene sheet. Mortality counts were made at intervals, and at each count both live and dead millepedes were removed from the pots and new batches of 30 millepedes added. In this way it was possible to make some estimate of the persistence of the different insecticides and the results are summarized in Fig. 2.

DISCUSSION

With all the insecticides tested there was some degree of mortality of the millepedes, but some materials appeared to be much better than others. The results obtained in the laboratory experiment were more clear-cut than those of the field experiment, probably because in the latter it was impossible to eliminate the migration of millepedes from treated to untreated plots and vice-versa. Evidence that such migrations occurred can be seen from the mortalities

that occurred in the control plots (Fig. 1). In the pot experiments the mortalities in the untreated pots were so low that they could be ignored.

Nevertheless the relative effectiveness of the different insecticides seen were demonstrated by the field data and were confirmed in general in the laboratory. Lindane and dieldrin did not show a significant mortality in the early counts from the field trial, but were markedly persistent and after a month the infestations in these plots were reduced to a very low level. Both of these materials, and also DDT and aldrin (dust), showed a similar pattern of effectiveness in the pot experiments (Fig. 2).

TABLE 2

Numbers of Dead Millipedes in Field Trial
(Counts in six-inch Quadrat)

Treatment	Days after treatment							
	4		10		19		25	
	Mean	±	Mean	±	Mean	±	Mean	±
Diazinon	18·2	7·3	18·5	12·8	4·2	1·8	—	—
Lindane	17·3	12·9	50·1*	10·6	56·7*	40·5	84·1*	44·2
Parathion	46·0*	24·3	39·2*	24·8	25·2	36·0	17·0	9·6
Naphthalene	25·0*	16·0	25·0	14·2	11·6	9·0	—	—
Dieldrin	8·3	7·2	19·4	9·9	44·5*	29·2	40·0*	29·4
Phosdrin	8·5	14·5	12·6	13·2	7·0	7·3	7·9	4·4
Nicotine	32·2*	12·1	41·2*	36·4	3·7	1·4	—	—
Control	2·2	0·8	3·8	2·9	3·2	3·0	2·7	1·9
Significant Difference (p = 0·05)	19·7		22·8		31·2		24·2	

* Significantly different from control at (p=0·05)

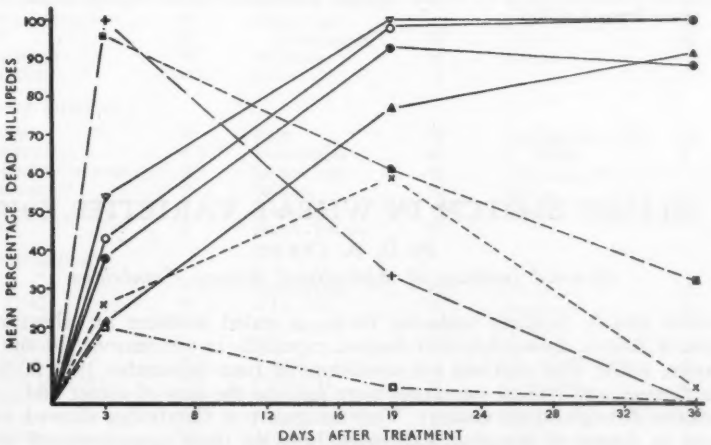

Fig. 2. Millepede mortality in the laboratory experiment.
(For key to symbols see Fig. 1)

Of the other materials tested parathion initially gave a very good kill in the field experiment, but was not very persistent. In the laboratory parathion was not very effective at any stage. These differences may be accounted for by the absorption of parathion into the peripheral layers of the stem and roots of the cucumber plants. Plants dipped into a solution of parathion and then allowed to dry were still lethal to millepedes which fed upon them.

On the other hand nicotine and naphthalene gave much better control in the pot experiments than that estimated in the field applications. This can be readily explained on the basis of the fumigant action of these two materials. The millepedes which were repelled by the vapour could easily escape in the field applications, and such migrations were in fact noted, but in the laboratory they were enclosed in a confined space with the vapour and quickly succumbed. The practical application of this observation was tested in a small field trial, where cucumber beds were treated with nicotine and naphthalene and immediately covered with large sheets of polythene. The mortality estimated by counts after three days was considerably higher than in the first field experiment for both materials. The mortalities were 62 per cent for naphthalene and 74 for nicotine as compared with 53 and 57 per cent respectively in the first field trial.

SUMMARY

Control of *O. gracilis* lies first in glasshouse hygiene, particularly in the use of steam sterilization and thorough cleaning of the glasshouse between crops. Where heavy infestations are expected rapid kills can be obtained by the use of nicotine or parathion drenches, but for long term control the application of one of the chlorinated hydrocarbon insecticides, in particular DDT or lindane, seems to offer the best results.

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GLUME BLOTCH IN WHEAT VARIETIES, 1958

by D. A. DOLING

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GLUME blotch, *Septoria nodorum* Berk., is stated to occur on wheat in all parts of Britain during July and August, especially in wet seasons (Moore and Moore, 1950). The cool and wet conditions of June–September 1958 favoured the disease, and typical symptoms were seen on the ears of winter and spring varieties throughout the country. Varieties grown at Cambridge showed differences in degree of symptom expression, and on them assessments of glume blotch were made, together with observations on the amount of shrivelled grain and on the incidence of seed-borne *Septoria nodorum*.

Sixty-seven winter wheat varieties, of which 19 were also sown in the spring, and 26 spring wheat varieties were sampled at harvest by taking three grab samples from small observation plots each totalling 16 feet of drill length, the total number of ears from each plot being between 12 and 28. In the first place an eye assessment of glume blotch was made on each sample as a whole, using the categories " nil," " trace," " slight," " moderate " and " severe." These assessments, made on the stored samples in March 1959, were as shown in Table 1.

TABLE 1

Eye-Assessments of Severity of Glume Blotch on Wheat Varieties at Cambridge, 1958

No Infection								
Artois-Desprez	....	W	Hesbignon	....	W	Stella	....	W
Atson	....	S	Idéal Bataille	....	W	920/54	....	W
Carpo	....	S	Jufy I	....	S	9/3/1	....	W
Traces Only								
Bonus	....	W	Koga II	....	S	Svenno	....	S
Burgweizen	....	W	Masters 57	....	W	Squarehead's Master 13/4	....	W
Dippes Triumph	....	W	Merlin	....	W	S.80	....	W
Elite Lepeuple	....	WS	Norrona	....	S	Yeoman	....	W
ELS	....	S	N. 59	....	W	14431	....	W
Fleuron	....	W	Pilote	....	W	524	....	W
Juliana	....	W	Professeur Marchal	....	W			
H. 91	....	W						
Slight Infection								
Alcy	....	W	FD. 467	....	W	Poncheau	....	W
Alfy II	....	S	Gilma	....	W	Probat	....	S
Apollo	....	W	Hadmersleben 5207	....	W	Rudest	....	W
Ardennes-Desprez	....	W	Heurtebise	....	WS	Starke	....	W
Ardennes-Desprez	....	WS	Hybrid 46	....	W	Sv. 01200	....	S
Atle	....	S	H. 88	....	W	TB. 22/18	....	W
Banco	....	W	Maître Pierre	....	W	TB. 31/23	....	W
Bersee	....	WS	Mariau Bataille	....	W	Vaillant	....	W
Cappelle-Desprez	....	WS	Mauerner	....		Vaillant	....	WS
Elite Lepeuple	....	W	Unbegrannt	....	W	1144/53	....	W
Erli	....	S	Minister	....	W	14764	....	W
Flamingo	....	W	Peko	....	S	630/54	....	W
Fleuron	....	WS						
Moderate Infection								
Bersee	....	W	Frio	....	W	Sundhausen 920		W
Burgweizen	....	WS	Heurtebise	....	W	Sv. 01281	....	S
Cappelle-Desprez	....	W	Little Joss	....	W	Vilmorin 53	....	S
Dominator	....	W	Milfast	....	W	Werna	....	S
Drott	....	S	Redman	....	W	14802	....	W
Felix	....	W	Short Bersee	....	W			
Severe Infection								
Alcy	....	WS	Dominator	....	WS	Phoebus	....	S
ALG/42	....	W	F.D. 467	....	WS	Samland	....	W
Apollo	....	WS	Flamingo	....	WS	Selkirk	....	S
Arletta	....	W	Frio	....	WS	Staring	....	W
Arletta	....	WS	Fylgia	....	S	Sv. 01280	....	S
Artois-Desprez	....	WS	Fylgia II	....	S	Teutonen	....	S
Banco	....	WS	Holdfast	....	W	14789	....	W
Bonus	....	WS	Jufy II	....	S	5050	....	S
Coutiches	....	W	Marne-Desprez		W	5583	....	S
Dippes Triumph	....	WS	Miche	....	W			

W=Winter wheat, winter sown. S=Spring wheat, spring sown. WS=Winter wheat, spring sown.

A more detailed examination of the ears in each sample was then made, also in March 1959, when each individual ear was scored for glume blotch according to the following scale:

A.	"Slight"	Ears with no symptoms, or typical symptoms on occasional glumes only.
B.	"Moderate"	Ears with typical symptoms on most glumes but of superficial appearance.
C.	"Severe"	Ears with dark blotches on all glumes.

A disease index figure for each variety was then calculated by adjusting the total number of ears for the variety to fifty, and using weighting factors 0 for A, 1 for B, and 2 for C, giving:

$$\text{Glume Blotch Index} = (A \times 0) + (B \times 1) + (C \times 2)$$

The order of the varieties in respect of severity of glume blotch infection, as found by the disease-index method, was similar to that by eye-assessment. Spring varieties were not more severely infected than winter varieties and within each group no correlation between severity of glume blotch and date of earing was detected. This may have been due either to uniform epidemic conditions throughout the period of ear susceptibility or to a wide variation in physiological susceptibility of the varieties of each group.

Table 2 gives the Index figures for 19 winter wheat varieties which were sown on November 6, 1957 and also on March 6, 1958. In general the level of infection was higher in the second sowing than in the first, suggesting that resistance is associated with the stage of maturity of the ears. A moderate degree of physiological resistance, however, was indicated in the varieties Ardennes-Desprez, Bersee, Bonus, Fleuron and Heurtebise, as the level of infection for each of these was relatively low and similar for both of the sowing dates.

TABLE 2

Glume Blotch Index Figures for Winter Wheat Varieties Sown on November 6, 1957 and March 3, 1958

(100 = All Ears Severely Infected)

Variety	Index		Variety	Index	
	November Sown	March Sown		November Sown	March Sown
Arletta	46	79	Frio	24	55
Ardennes-Desprez	41	44	Vaillant	24	45
Bersee	41	44	Alcy	21	57
Cappelle-Desprez	35	56	Dominator	20	48
Bonus	31	30	Banco	19	43
Burgweizen	29	40	Fleuron	18	26
Flamingo	29	57	Elite Lepeuple	11	24
Heurtebise	27	24	Dippes Triumph	10	26
Apollo	27	53	Artois-Desprez	6	27
FD 467	26	50			

EXAMINATION OF THE GRAIN

After completion of the disease assessments, the ears were carefully threshed and the percentage of shrivelled grain determined. Data for the winter-sown

varieties are shown in Fig. 1. Varieties with slight glume blotch symptoms had very little shrivelled grain, indicating that other causes of shrivelling were absent from the trial plot. At moderate levels of infection the percentage of shrivelled grain increased and at severe levels it increased still further, indicating an association between the severity of glume blotch and the degree of shrivelling.

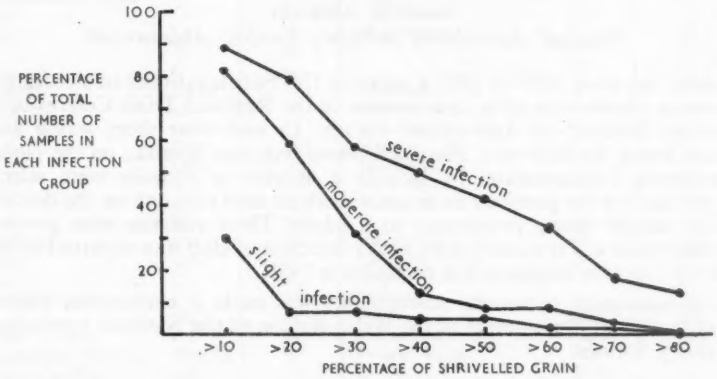

Fig. 1. Percentage of samples with over 10 to over 80 per cent of shrivelled grain for three levels of glume blotch infection. (Winter-sown plots only).

Twenty-six samples from varieties showing different amounts of glume blotch were tested for seed-borne *Septoria nodorum*. From each sample one hundred seeds were surface-sterilized by dipping in sodium hypochlorite solution (1 per cent available Cl) for 10 minutes, plated on to potato-dextrose agar and incubated at 23° C for 5 days. The variety Alcy had 14 infected seeds in the sample from the winter-sown plot and 4 in that from the spring-sown plot. The spring-sown plots of Banco and Frio had 5 infected seeds and the remaining 22 samples had either 1 or 0 infected seeds. A few seeds in each sample examined were infected with *Fusarium nivale* (Fr.) Ces. Within the limits of the small sample size there appeared to be no relationship between seed-borne *Septoria nodorum* and disease symptoms on the glumes. The general level of infection of the seed was low.

SUMMARY

The relative severity of glume blotch was assessed by two methods in ninety-three wheat varieties grown at Cambridge in 1958. In a comparison of nineteen varieties sown in the winter and also in the spring glume blotch was generally more severe on the plants in the second sowing. Shrivelling of the grain was found to increase with severity of the symptoms, but the incidence of seed-borne *Septoria nodorum* was generally low and unrelated to the disease level on the ears.

I wish to thank Miss E. F. Ford, Miss K. E. See, and Mr. M. H. Meadway for their assistance in this work.

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RESISTANCE OF VARIETIES OF SWEDE TO CLUB ROOT

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DURING the years 1953 to 1955 a series of 136 British varieties of swedes were grown in observation plots at a number of the Regional Trials Centres of the National Institute of Agricultural Botany. In each year there was a fairly severe attack by club root, *Plasmodiophora brassicae* Woron., on the plots at Trawscoed, Cardiganshire. In 1956-58 a number of varieties were selected on the basis of the previous three years work on club root and on the demands of the variety testing programme as a whole. These varieties were grown in detailed trials at Trawscoed and a heavy infection of club root occurred in 1956 and 1957, but the incidence was negligible in 1958.

The assessment of varietal susceptibility was made in conjunction with the Plant Pathology Department of the Welsh Region of the National Agricultural Advisory Service.

METHODS

In the observation plots (1953-55) the plot size was 1/200th acre with an average population of 110 roots. Of these, 20 roots, selected at random, were examined and classified as:

Free	= roots completely free from outward sign of the disease.
Nodules	= roots with at least one nodule about $\frac{1}{4}$ inch diameter.
Small galls	= roots with galls from $\frac{1}{4}$ to $\frac{1}{2}$ inch diameter.
Large galls	= roots with galls larger than $\frac{1}{2}$ inch diameter.
Severe	= roots with the bottom completely distorted by the disease.

In the trials (1956-58) the plot size was reduced to approximately 1/400th acre, and the varieties were grown in a randomized-block layout of four replicates. All the roots were examined and classified. In 1957, the classification was modified by extending group " Free " to include " Nodules," as laboratory examination of the nodule tissue of the previous year's material had generally not disclosed presence of the disease.

RESULTS

The data for the varieties in the observation plots (1953-55) are given in Table 1. The percentage infection has been calculated on the scale, 0 for free, 1 for nodules, 2 for small galls, 4 for large galls and 5 for severe damage. Thus a variety with 20 roots in the severe category will be recorded as 100 per cent infected.

In Table 2, which gives the mean data for the trials (1956 and 1957), this percentage scale has been modified to 0 per cent for free, 10 for nodules, 20 for small galls, 70 for large galls and 100 for severe damage. In addition the numbers of roots with large galls or severe infection per 100 roots are given.

There were 14 varieties grown in all observation plots and trials (1953-58) and the mean data for these are given. The percentage infection data has been subjected to angular transformation.

TABLE 1

Mean percentage infection. Observation Plots, 1953–55

Variety		Infection *per cent*	Variety		Infection *per cent*
Aberdeenshire Prize	B	58	Lord Derby C		45*
Acme	G	62	Longkeeper .... Cr		52
Angus	I	48	Magnificent C		48
	W	66		G	57
A.I.	S	64		H	63
Balmoral	BRH	55	Mancunian .... H		45
Bangholm	H	51	Masterpiece .... Wb		60
Best of All	CWS	52	Mayday C		52*
	C	38*	Mervue .... B		61
	DBT	40	Middlefield .... Wt		62
	E & L	37*	Midlothian .... Cr		59
	E & L	42	Monarch .... CT		59
	H	36		H	55
Broadland	Cl	58	Nailstone Cl		66
Buffalo	Wb	54	Ne Plus Ultra .... H		55
Clyde	Cs	62	99 .... Cr		66
Conqueror	C	48	Parkside .... G		59
	DBT	54	Peerless .... McG		60
Cornish Model	CT	61	Perfection .... CT		58
Corstorphine DS 2	SSRPB	57	Purple King Cl		59
Coxton Crofter	RP	31	R. 34 .... McG		55
Danestone	BRH	43	Springwood .... B		59
Darlington	BRH	39*	Superlative C		43
Defiance	D	45		G	32
Devon Champion	T	59	Teviotdale L		15*
Doon Major	McG	61	Tipperary .... Cr		57
Drummonds Purple Top	CT	57		CWS	55
	Dd	57	Townhead .... G		66
Eclipse	C	47	Victory .... B		66
Edina	Wt	56	Viking .... B		56
Elephant	B	65	Waterloo .... Wt		54
Empire	F	63	Whalleys .... S		58*
Excellsior	C	65	Whitefleshed C		62
Gateacre	C	55		H	66
Giant Tankard	Cl	61	Wilhelmsburger	BRH	14
Green Top	B	62*		B	15*
Imperial	Wb	57		Cl	16*
Improved Bronze Top	B	42		H	20*
Invicta	Cr	58	Wintergreen	Cs	66
Iverquhomery	CT	66	XL All	CT	37
	H	60			
Jubilee	L	51	Significant Difference ($p = 0{\cdot}05$)		23·8
Knockdon	Cs	42*			
Lion	Cl	52	Mean for 14 common varieties		37*

SUPPLIERS

B	David Bell, Ltd.	G	Gartons, Ltd.
BRH	Barclay, Ross & Hutchinson	H	Hurst & Son, Ltd.
Cl	Cannell & Sons, Ltd.	I	Charles Irvine & Sons
Cr	Alexander Cross Seed Co., Ltd.	L	Peter Lawson & Son, Ltd.
CT	Cooper Taber & Co., Ltd.	RP	Roughead & Park
Cs	Carters Tested Seeds, Ltd.	McG	McGill & Smith, Ltd.
C	Thomas Cullen & Sons	S	Charles Sharpe & Co., Ltd.
CWS	Co-operative Wholesale Society, Ltd.	SS	Scottish Society for Research in Plant Breeding
DBT	Dickson, Brown & Tait, Ltd.		
Dd	W. Drummond & Sons, Ltd.	T	Edwin Tucker & Sons, Ltd.
D	Dunns Farm Seeds, Ltd.	W	William Watt (Seedsman), Ltd.
EL	Eastes & Loud, Ltd.	W	Edward Webb & Sons (Stourbridge), Ltd.
F	Samuel Finney & Co., Ltd.		

TABLE 2

Mean results of Trials in 1956 and 1957

Variety and Supplier	Skin Colour (B)ronze (G)reen (P)urple	Infection (by scale) *per cent* 1956	1957	Count of roots with large galls or severe infection *per cent* 1956	1957
Best of All	B	P	24	—	15	—
	Cs	P	—	35	—	34
	C	P	23	25	15	21*
	DBT	P	25	—	18	—
	D	P	—	26	—	18
	EL	P	22	19	13	14*
	H	P	24	—	18	—
	Sr	P	—	20	—	14
Coxton Crofter	B	P	7	10	0	4
	RP	P	11	11	2	4
Danestone	BRH	P	27	—	20	—
Darlington	BRH	B	31	29	26	35*
Defiance	D	P	—	32	—	32
Drummonds Disease Resisting	Dd	G	4	3	0	0·5
Greentop	B	G	32	31	30	32*
Greentop Ingleston	McG	G	26	—	22	—
Halewood	C	B	26	20	16	28
Improved Bronze Top	B	B	32	23	26	45
Jubilee	H	G	30	28	31	29
Kinaldie	L	G	14	16	4	8
Knockdon	Cr	P	30	20	24	14*
Lord Derby	C	B	45	28	23	21*
Magnificent	C	P	—	22	—	22
Mancunian	C	B	—	36	—	37
May Day	C	G	26	33	23	33*
Superlative	C	P	24	—	17	—
	G	P	—	22	—	12
	H	P	—	24	—	17
	S	P	—	23	—	17
Teviotdale	L	G	13	9	6	4*
Warrington	G	P	23	22	6	14
Whalleys	S	G	33	28	34	28*
Wilhelmsburger	BRH	G	9	5	0·6	1*
	B	G	9	4	1	1*
	Cs	G	11	8	2	3
	C	G	7	5	0	2*
	H	G	14	14	2	4*
	S	G	8	6	0	0·5
Wintergreen	Cr	G	32	33	27	30*
XL All	F	B	31	—	30	—
Y (New Zealand)	B	B	—	0	—	0·5
Cabbage			12	—	2	—
Giant Rape			42	—	51	—
Marrow Stem Kale			7	—	0	—
Turnip			10	—	3	—
Significant Difference (p=0·05)			11·0	11·1	16·2	16·9
Mean of 14 common varieties *			24	19	16	17

For key to suppliers see footnote to Table 1.

DISCUSSION

The constant selection undertaken in the seed multiplication of swede varieties may alter the detailed character of a variety, this makes it essential to identify the variety by the name of the seed supplier. It also makes more difficult the comparison of results with those obtained earlier (Whitehead 1940).

A number of varieties in these observation plots and trials appeared to be resistant to club root, notably Coxton Crofter (Bell), Drummonds Disease Resisting (Drummond) and Wilhelmsburger (Barclay, Ross and Hutchison–Bell–Cullen–Gartons–Sharpe). A number of others also showed a fair measure of resistance, such as Coxton Crofter (Roughead and Park), Kinaldie (Lawson), Teviotdale (Lawson), Wilhelmsburger (Carters–Hurst).

Wilhelmsburger has been noted by many British workers as being resistant (Findlay 1931, Small 1935, Bennett 1939, Whitehead 1940). The New Zealand variety which showed a high degree of resistance in 1957 trial, is a Wilhelmsburger selection (Wallace 1943). There is also some agreement with Whitehead (1940), that some selections of Superlative possess a measure of resistance greater than other light purple varieties. The results do not support, however, Beaumont and Staniland (1933) in suggesting that Balmoral is less susceptible than Eclipse, Magnificent and Tipperary.

It is known that there are physiologic races of *Plasmodiophora brassicae* resulting in differential reaction for particular host species (Macfarlane 1955). It has been suggested for swedes (Canada 1951) and for turnips (Scheijgrond and Vos, 1954) that there may be a differential reaction for varieties. Also the intensity of the attack may influence resistance; Bennett (1939) has reported that the resistance of Wilhelmsburger broke down under conditions of severe infection, and Olsson (1940) had similar results with a number of varieties. The application of these results to a different environment therefore must be made with some caution.

The covariance of the two methods of recording the degree of infection as percentage infection and as a number of roots infected, was significant (0·01) in 1956 but not in the following year. The counting of the markedly affected roots is the more rapid method. The regression coefficients of dry weight on the number of roots infected was not significant in either 1956 or 1957.

The authors wish to thank Mr. W. M. R. Evans, Mr. H. Jones and the staff of the Trawscoed Experimental Husbandry Farm for their help and assistance during the course of the investigations.

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A METHOD OF ASSESSMENT OF APPLE POWDERY MILDEW

by JUNE V. BAKER (*née* IVES)
National Agricultural Advisory Service, Cambridge

DURING 1955, anxiety was expressed by some apple growers in East Anglia about the increase in apple mildew. *Podosphaera leucotricha* (Ell. and Everh.) Salm. in their orchards. Various explanations for the increase were current at the time, popular ones being the continued application of renewal or regulated techniques of pruning (which involve leaving longer extension shoots to overwinter) and the use of captan, which was proving valuable against apple scab, but appeared to be ineffective against mildew. All too little was known about the epidemiology of apple mildew, and its seasonal occurrence. There was limited information only on the prevalence and seriousness of the disease and records often failed to reveal the current symptom picture in the orchard.

A survey of apple mildew was therefore undertaken in the Eastern Region, and in the course of the work, which continued over three seasons, observations were made on the carry-over of the disease from year to year, and methods for assessing it in its various phases were worked out. Orchards for examination were confined to the variety Cox's Orange Pippin, and within this variety to those on the Malling root-stock, type II. Information was obtained concerning methods and dates of operations carried out in the orchards, spray materials used, details of soil structure and chemical analysis, and type of tree growth.

It became apparent that the symptom expression of mildew on the trees in any one season is related to three years' life history of the disease. Assessments at different times in the growing season can indicate how much mildew must have been present in the previous season, and how much may be carried forward to the following year. A single "amount of mildew" record for an orchard therefore appeared to be inadequate for the purpose of the survey, and in fact three sets of observations were made; the first in the spring, at blossom time, the second in the early summer at the late fruitlet to swelling stage, and the third after growth had ceased in the autumn.

The sampling procedures, and the keys worked out for the use at each time of observation are now assembled in summary form on page 33. The following sections give the purpose, requirements and practical difficulties of assessment at each of the three times; and finally an example is given of the mildew records in two orchards in the survey in each of the three years, 1956, 1957 and 1958.

ASSESSMENTS IN THE SPRING

Assessment of established mildew on the shoots and in the flower trusses at blossom time provided a picture of the amount of mildew in the orchard resulting from infection in the previous growing season.

It was found that a satisfactory record of mildew on the SHOOTS could be made only where "coarse" pruning had been done, that is to say, where the pruners had not especially removed many mildewed shoots during the winter or carried out tipping of shoots throughout the orchard. Where "fine" pruning

SAMPLING PROCEDURE AND KEYS

		Mildew *per cent*	
SPRING	SHOOTS		Examine 10 shoots on each of 10 trees, or 5 shoots on each of 20 trees.
		1	Tip of shoot only affected. Terminal bud dead or distorted.
		15	Some silvering and dead lateral buds.
		60	Most of shoot silvered, and lateral buds, if breaking, giving weak or mildewed growth.
		100	Whole shoot infected.
	FLOWER TRUSSES		Examine a run of 10 trusses on a branch, or a group of 10 trusses on spurs on old wood, in 5 places on each of 10 trees. Express total number of affected trusses in 500 as a percentage.
EARLY SUMMER	LEAVES		Examine 5 shoots of current season's growth together with the spur leaves on the previous year's wood behind them, on each of 10 trees.
		1	One leaf here and there with lesions.
		10	Up to half the leaves on the shoot affected.
		50	Most leaves affected, but green colour predominating.
		75	Mildew severe, white areas predominating on all lower surfaces of leaves.
		100	Whole shoot defoliated, due only to secondary infection.
	SHOOTS		Same sample as for leaves.
		1	Terminal bud only affected.
		15	Up to one quarter of shoot whitened.
		60	One quarter to most of shoot whitened.
		100	Whole shoot whitened.
AUTUMN	SHOOTS		Examine 10 shoots on each of 10 trees, or 5 shoots on each of 20 trees.
		1	Terminal bud only affected.
		15	Up to one quarter of shoot silvered.
		60	One quarter to most of shoot silvered.
		100	Whole shoot silvered.
	SPUR BUDS		Examine a run of 10 spur buds on a branch, or a group of 10 spur buds on old wood, in five places on each of 10 trees. Express total number of distorted buds in the 500 as a percentage.

had been done, different lengths of shoot were left behind, some still showing silvered areas and others not, so that the original amount of mildew on all shoots for the previous year could not be assessed.

By blossom time, wood silvering was not always apparent, but distortion of consecutive buds, from the terminal back along the shoot, and unusually slow development of lateral growth from affected buds, proved to be sufficient guides for assessment. Only main shoots produced the previous year were recorded, short shoots or dards being disregarded.

Occasionally a high proportion of shoots in an orchard bore dead terminal buds, with no silvering or lateral bud distortion behind them. Frost damage or nutritional abnormalities became suspect in such orchards, and only those terminal buds which were definitely distorted were counted as "mildewed." It is worth noting here that whereas affected shoots in the 1 per cent to 60 per cent range represented growing point infection in the previous growing season, many 100 per cent infected shoots probably derived from terminal or lateral bud infections the season before that.

In the assessment of mildew on the FLOWER TRUSSES, it was found that almost all those breaking from buds affected with mildew in the previous season were completely covered with spores and were readily distinguished from their healthy counterparts, but occasionally partially affected trusses were found. If lesions occurred on both upper and lower surfaces of the leaves they were counted as affected.

ASSESSMENTS IN EARLY SUMMER

The object of assessment at the late fruitlet to swelling stage was to obtain records after secondary leaf infection had become apparent, and fresh wood infection was developing. An endeavour was made to do the recording at this stage in all orchards in the survey as nearly possible at the same time and before the lesions on the spur leaves had become so weathered as to be obscured.

Assessments were made on fifty rather than one hundred shoots per orchard at this stage, as examination of the LEAVES was more time consuming than the other counts, and an adequate picture of the amount of secondary mildew they carried was obtained with the reduced amount of sampling. In practice it was found that over 50 per cent of mildew on the leaves, as defined by the key, was very rarely recorded. Purpling of the underside of a leaf may often have been an indication of the earlier presence of mildew, but purpled leaves were not counted as mildewed in the assessments as the symptoms were too indefinite. Curling of the leaf margins were also ignored unless a mildew lesion was clearly visible.

Assessment of mildew on the surface of the new SHOOTS at this stage, in addition to those on the expanded leaves, showed up the extent to which the growing points of the current season's growth had become infected—as manifested by the coating of spores on both surfaces of their leaves, and a basipetal whitening of the stems.

If a shoot had completed its growth for the season, and had become infected in the terminal bud only, then the only visible sign of infection was a thinness and slight twisting of the bud, often with an unprotected tip, in contrast to a plump, compact, healthy bud, well protected by broad-based scales. The 1 per cent category in the key was devised to record such abnormal terminal buds. When shoot infection was recorded as 15 or 60 per cent, the secondary infection of the leaves below the whitened area could be compared with similarly placed leaves on comparable new shoots without wood infection, and leaf infection recorded accordingly. The extent of defoliation, generally occurring in summer on whitened shoots, was noted.

ASSESSMENTS IN THE AUTUMN

Assessments after the cessation of growth but before winter pruning served to indicate the final amount of mildew for the season. The recording was done before or after leaf fall, preferably while the affected wood—now appearing silver, rather than white, as it ripened—was still clearly visible.

A terminal bud infection in the autumn probably corresponds to about 1 per cent shoot infection in the following spring. If the bud dies during the winter, a short part of the shoot tip behind it may also die. It was found to be relatively easy in the autumn to distinguish between 1 per cent and 15 per cent shoot infection. If the small buds, sometimes found on the shoulders of the shoot tip on either side of the terminal bud, were distorted, the shoot was classified as 1 per cent. In some orchards a few recently affected terminal buds were to be found which had burst prematurely giving completely mildewed secondary growth. Any silvering visible below the tip, up to one quarter of the length of the shoot, was assessed at 15 per cent.

In the survey, completely affected shoots were included in the summer and autumn counts. Such shoots may represent infection from the previous rather than the current year since they develop from infected terminal buds or lateral buds near the tip of a mildewed shoot. There would therefore be a case for excluding completely mildewed shoots, if a mean of the current season's infection were the only requirement. But it was included, as a measure of the total load of inoculum was considered to be of value, and, in addition, the presence of such shoots contributed to a certain loss of vigour due to mildew in the tree during the season.

As a part of the autumn assessment a count was made of the percentage of mildewed BUDS. It was not difficult to distinguish, in most orchards, between healthy buds and those distorted by mildew, but unfortunately the counts of mildewed buds were not always complete, as often more were infected by mildew than could be seen by the naked eye.

Distorted buds may occur on spur wood which is a normal brown colour, and on spur wood which is silvered from an earlier attack, this being the difference between "secondary" and "primary" bud infection. Where "secondary" bud infection is apparent, either spores or mycelium of the fungus have penetrated the young bud tissues before they were sealed off by their scales, in the current season (Burchill, 1957; Woodward, 1927) whereas with "primary" bud infection the attack originated in a previous season, will have shown up as a completely affected blossom or leaf truss in the current season, and it will remain as a silvered, stunted spur bearing small shaggy buds in the autumn. These primarily infected buds were included or excluded, according to whether a figure was needed for total bud mildew, or for the season's secondary bud infection only. In relation to the vigour of the trees and fruit yield, they are of importance, and to be included; in relation to mildew infection during the current season they are misleading and to be excluded. In the survey in the Eastern Region they were included in the first, and excluded in the second and third years.

SAMPLING PROCEDURE

In the survey, the spring, summer and autumn assessments were made on ten or twenty trees in each orchard. Outside rows were avoided, and, in general, alternate trees in a row, and alternate rows in an orchard, were chosen. Samples were taken at different sites around the tree, with a slight conscious endeavour to circumambulate the tree (thus taking in shoots sprayed at different angles by

the sprayer) and to record at different heights from nearest soil level up to stretched arm level and at different positions, within the canopy to around the circumference of the tree. The actual shoots assessed were taken in a non-selective, haphazard manner. The method could not be described as random sampling; and while it proved satisfactory for comparing the incidence of mildew in different orchards or part orchards, at different seasons, it can only indicate trends, in a statistical sense; fairly large differences in the mean assessment figures are needed to indicate real differences in amount of mildew.

EXAMPLES OF MILDEW RECORDING

At the end of each season, six or seven sets of figures had been obtained for each orchard or part of an orchard surveyed; and these were then used for comparisons. The mean figures for two similar orchards in the Wisbech area in 1956, 1957 and 1958 are given in Table 1. Most of the records were made in the two orchards on the same day. Both orchards (A and B) were of Cox's Orange Pippin bush trees on type II rootstock planted in 1936 on the flat, and by 1958 were tumbledown. Both were on silty loam over silt or clay, and showed a tendency to mineral deficiency symptoms. Both orchards were sprayed with captan in 1955 and 1956. Orchard A had sulphur with captan in 1957 and 1958; orchard B had sulphur with ziram in those years.

TABLE 1

Mean Percentage Mildew Assessments on two Cox Orchards in the Wisbech Area

Orchard and Year	Spring		Summer			Autumn	
	Shoots	Flower Trusses	Leaves		Shoots	Shoots	Buds
			On Spurs	On new Shoots			
A							
1956	27 (0·8)	4·6	6·3	10·8		97 (21·7)	9·0
1957	95 (4·9)	7·6*	7·0	49·0	32 (11·4)	81 (29·9)	24·0
1958	92 (30·3)	*2·2	4·1	49·0	58 (33·3)	86 (38·3)	9·0
B							
1956	2 (0·02)	0	0·4	0·9		38 (2·8)	2·6
1957	36 (1·5)	1·7	1·4	37·3	28 (23·8)	37 (19·1)*	4·0
1958	Tipped	11·6	16·6	48·5	76 (56·0)	86 (47·9)	24·4

Figures in brackets give mean percentage length of the shoots silvered in spring or autumn or whitened in summer.

* Some affected parts removed commercially, before or after recording as indicated by position of asterisk.

In 1956 both orchards had quite good vigour and in Orchard B the canopy was large and spreading. In Orchard A, despite the heavy mildew infection of the shoots, and evident loss of vigour, the trees were still developing at a satisfactory commercial level in 1957 and 1958. In Orchard B, however, there was a dramatic decline in vigour, few shoots or buds being produced in 1958.

The main value of the sets of figures obtained in the survey as a whole (which embraced some 57 orchards) was to enable a study to be made of the behaviour of the disease, especially in the relationships between the amounts of mildew

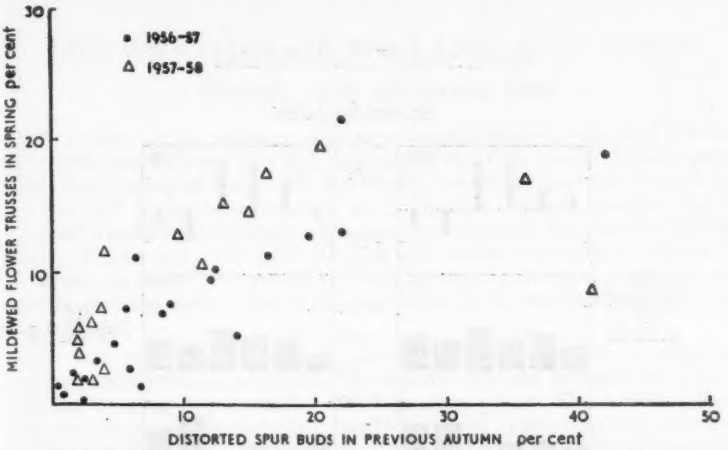

Fig. 1. Relations between mean percentage of mildewed flower trusses in spring and distorted spur buds in the previous autumn, for 21 orchards in 1956-57, and 17 orchards in 1957-58.

on different parts of the tree within one season, and from year to year. Fig. 1 shows, for example, the mean percentage of infected flower trusses in spring 1957 plotted against the mean percentage of distorted buds in autumn 1956 for 21 of the orchards in the survey and the same for infected flower trusses in spring 1958 and distorted buds in autumn 1957 for 17 of the orchards. There appears to be a direct correlation between the two. The proportion of distorted buds to infected flower trusses was greater in 1956-57 than in 1957-58. This may partly be accounted for by the inclusion of primarily infected buds in the records in the first season of the survey. It may well be that such buds are too weak to survive and produce flowers.

DISCUSSION

In the survey in the Eastern Region, some two dozen people used the mildew assessment methods. Usually two and sometimes three people made separate assessments on any one visit to an orchard. There was normally a similarity in the figures obtained by each observer, but where, on occasion, big differences were apparent, cross-checks were made. Tree to tree variation generally accounted for such differences.

Adaptations of the method may well be needed for trial work, according to the information desired. The method of leaf assessment, taken on its own, would, for instance, be of limited value for showing differences between treatments, unless the counts were taken very soon after the last anti-mildew spray of the season.

Thanks are due to Mr. G. H. Brenchley and members of the Plant Pathology Department at Anstey Hall and the horticultural advisory officers in the N.A.A.S. of the Eastern Region, who co-operated so generously in the survey.

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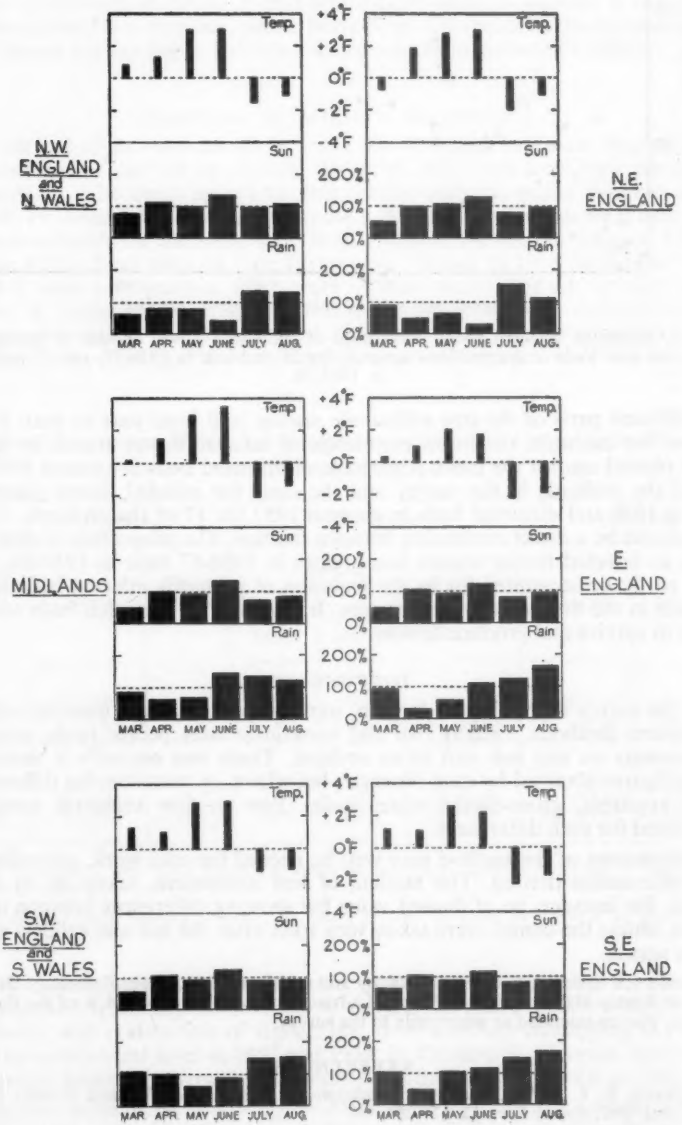
MARCH - AUGUST WEATHER 1960

Variations from Average



THE WEATHER OF ENGLAND AND WALES

SPRING AND SUMMER, 1960

AFTER a winter of wet weather, with near average temperatures and few really cold spells, March 1960 was dull and rather dry with predominantly easterly winds. Fogs occurred frequently but cloudy conditions prevented much frost. The first half of April was marked by changeable westerly weather, but later dry quiet conditions prevailed and it was very dry over the eastern half of the country. It was very mild about the 20th with cooler conditions to follow. May was decidedly warm and mainly dry and late spring drought conditions were, if anything, more severe than at the same time in the previous year. Few frosts were recorded.

June was generally warm and sunny, but several severe thunderstorms occurred, chiefly in the Midlands. Around the 4th and between the 17th and 25th, day temperatures exceeded 80° F in many places. The weather changed its character completely early in July which proved to be a cool wet month with frequent thunderstorms. Westerly unsettled weather was now firmly established and was to persist for the rest of the summer. August followed the July pattern with frequent rain, often of a thundery type and cool temperature conditions. A tornado swept part of Wiltshire and the Cotswolds on the 27th. Despite the cool air temperatures of July and August, earth temperatures remained near or slightly above average.

The weather for each of the six months March to August inclusive, is represented graphically on page 38. Figures for six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall. Outstanding features are the change in temperature regime which took place at the end of June and the dryness of the late spring and early summer. The wet conditions of July and August are also clearly shown.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

Scabbed Wood on Bramley's Seedling Apple. In August 1960 scab pustules were seen on the wood of a young leader on a 20-year-old unsprayed tree of this variety at Harpenden. The lesions were sporing freely and a further search revealed several more leaders similarly scabbed (Plate I, a). Many leaders with leaf infection on the tree were, however, free from any trace of wood infection. Blenheim Orange, Laxton's Superb and Cox's Orange Pippin in the same orchard all showed moderate amounts of wood scab, but it was not found on three other trees of Bramley's Seedling. In view of the well-known resistance of this variety to wood scab, a search was made for wood scab on it elsewhere. A single leader with sporing wood pustules (Plate I, b, with healthy wood for comparison c) was found in a 10-year-old regularly sprayed commercial orchard

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These notes and the diagrams on page 38 are provided by the Agricultural Branch of the Meteorological Office, and are published by permission of the Director-General.

of Bramley's Seedling at Elmsted, Kent, in September 1960. The trees in this orchard had no scab present on the fruit, but one or two per cent of the leaves were infected.

Although severe leaf and fruit infections have been seen on Bramley's Seedling since the finding by Salmon and Muskett of the perithecial stage of *Venturia inaequalis* in Kent and Ireland in 1923, and occasionally bud-scale infections are found, wood scab has not been noted on this variety. Salmon and Ware (*J. Pomol.*, 1925, **4**, 230-9) clearly searched for it, and in their report of a spraying trial in Kent mentioned that a few shoots bore small unburst swellings in which no mycelium could be found on microscopical examination. Ascospores from overwintering leaves are the principal source of infection in this variety, but it would appear incorrect to assume that it is entirely free from scab on the wood. (Photograph by J. R. Morrison, Plant Pathology Laboratory, Harpenden).

T. F. PREECE

Sporulation of Blight on Potato Tubers within Ridges. *Phytophthora infestans* (Mont.) de Bary sporulates readily from the surface of diseased tubers kept in high humidity in the laboratory, and a search was made during the growing period in 1960 to see if this also happens in field crops. A crop of Ulster Ensign, known to have a high proportion of tubers infected, was first examined on August 8 after a period of rain, and on that and subsequent occasions the fungus was found to be sporulating in tufts from the lenticels and on crumbs of soil attached to the surface of unexposed blighted tubers within the potato ridges (Plate II, 1). Sporulation, usually from lenticels but sometimes from eyes, was also found on infected tubers of King Edward on August 15, and of Arran Banner and Up-to-Date on August 25. Jones and Morse (*Ann. Rep. Vermont Agr. Exp. Sta. for 1904-5*, **1905**, 272-91) reported sporulation on tubers of the variety 'State of Maine' within ridges, and they attributed the increase in the number of blighted tubers on successive samplings, after the haulm had died, to spread of the fungus from these sporing tubers. They suggested that sporulation occurred only in excessively wet seasons and on heavy land, but in 1960 I found infected tubers of King Edward sporing at Rothamsted in a flinty loam with heavy sub-soil and at Woburn in a light sandy loam. Sporing tubers were readily found when the ridge was drying after rain, but were difficult to find during or immediately after further rain, presumably because spores were washed off; these spores must supplement those washed down into the soil from the blighted haulm. Sporulation is not necessarily restricted to the varieties mentioned and it may spread blight from tuber to tuber especially in varieties whose tubers are close together within the ridge.

D. H. LAPWOOD

Downy Mildew of Chrysanthemum. Dark pin-heads (Plate II, 2) on both surfaces of the outer florets of the American spray variety 'Yellow Top' were found to consist of conidiophores and conidia suggestive of *Peronospora* spp. The conidia were dark violet in mass, ovate, and measuring 22–36 $\mu \times 18$–25μ (mean 28×19 μ). A small number of oospores (mean diameter about 30 μ) were also present in the tissue of affected florets. No leaf infection could be found. The plants were growing in a bed 35 ft $\times$ 4 ft in an unheated double span glasshouse at Walberton, West Sussex, and at least 40 per cent of the blooms were affected. The fungus was also found on the varieties White Top, Igloo, Iceberg and Shasta in adjoining beds, but no infection could be found on Yellow Shoesmith in the same house. A conidial suspension was sprayed on to healthy flowers of the varieties, Yellow Top, and Shasta and incubated

under polythene for 48 hours. Inoculations proved successful on these varieties but not on several mid-season varieties or on Shoesmith.

Infected material was sent to Miss Grace Waterhouse at the Commonwealth Mycological Institute, and to Dr. F. Joan Moore of the Plant Pathology Laboratory, Harpenden, both of whom identified the fungus as *Peronospora radii* de Bary. This appears to be the first record of downy mildew on cultivated chrysanthemums, although it has been found in several European countries on Composite weed hosts, including *Chrysanthemum leucanthemum* and *Matricaria inodora* (Gäumann, E., *Beiträge zu einer Monographie der Gattung* Peronospora *Corda*, 1923, Zurich).

H. J. WILCOX

Root-knot Eelworm on Nursery Plants. *Meloidogyne hapla* Chitwood was identified in the following outdoor ornamental plants sent to the Plant Pathology Laboratory at Harpenden during 1958 and 1959 by T. Kingsley (N.A.A.S., Suffolk) and A. P. King (Plant Health Inspector, Hampshire):

Berberis hybrids 'Sibbertoft Coral' and 'Pirate King,' from Suffolk. The roots of these plants showed many small galls, typical of attack by *Meloidogyne hapla* (Plate III, 2, *left*). The eelworm was also found in roots of dandelions, *(Taraxacum officinale*, Weber) and *Geranium molle* L. which were growing as weeds among the infested *Berberis*.

Lonicera purpusii Rehder, from Suffolk, with typical small galls on roots.

Clematis 'Hagley hybrid,' from Suffolk; rooted cuttings (not grafted) with slight galling on roots.

Viburnum cassinoides L., from Hampshire. The plants were from cuttings rooted in a glasshouse and later stood out in cold frames. The roots bore many small galls which were mostly smooth and rounded and often terminal (Plate III, 2, *right*). The roots did not show excessive lateral branching associated with the galls, and so lacked the knotted appearance commonly found with *M. hapla* attacks. Fewer eelworms were present than was expected from the amount of galling and it was difficult to find them in some galls. Where females could not be found, however, careful search generally revealed larval stages. Galls containing females usually had broken surfaces and slight necrosis.

Lobelia cardinalis L. One heavily galled plant was received from Hampshire.

This last plant and the *Clematis* hybrid have not previously been recorded as hosts of *Meloidogyne hapla*. The other hosts mentioned above are included as *in lit.* records in the Supplement to Goodey and Franklin's nematode host catalogue (Goodey, Franklin and Hooper, 1959, *Commonw. Agr. Bur.*, Farnham Royal). The infested *Geranium* was recorded as *G. pyrenaicum* in the Supplement, but has since been correctly identified by Miss J. M. Thurston as *G. molle*.

J. F. SOUTHEY

Linnet Damage to Strawberry Fruit. In 1958 it was reported from Tiptree, Essex, that the linnet, *Carduelis cannabina cannabina* (L.), was causing considerable damage to strawberries in the area by pecking out the seeds from the fruit. According to several growers the damage was unknown until a few years ago and it may therefore be a recently developed habit. Damage appears to be more common on maidens but several severe attacks on the main fruiting beds have been seen. Good quality early fruit is produced by the maidens and several growers have been forced to abandon this crop and now practise deblossoming. During the last three seasons I have watched through binoculars

beds on which damage was occurring. On several occasions I have observed linnets perched on fruit trusses and pecking and finally wiping their beaks. I then found freshly damaged fruit on these plants. One grower once observed linnets damaging fruit which had just been picked and left in punnets between the rows. Other seed-eating species were not commonly seen on the strawberry beds.

Although the damage caused by linnets may be confused with that due to the strawberry seed beetle, *Harpalus rufipes* (Deg.) (Briggs, J. B., *Ann. Rep. East Malling Res. Sta. for 1956*, 1957, 142-5) it differs from it in several important respects. With both pests damage commences when the fruit turns white and continues on the ripe fruit. Both feed on the seed contents and discard the husks, which may be found on the fruit, leaves and ground. Linnets remove the seed without lacerating the fruit surface (Plate III, 1) and crack the seed neatly into two halves. Although on unripe fruit or on varieties with prominent seeds the beetles can remove the seed neatly and crack it, they usually lacerate the fruit surface, and seeds which have been bitten into rather than cracked may often be found *in situ* on the fruit. Fruit damaged by linnets deteriorates rapidly on the plants and is useless for marketing. Linnet damage occurs on the exposed side of exposed fruit only and is equally common on all parts of the plant. Occasionally groups of two or three seeds may be removed but often a large proportion of the exposed seeds are taken. Although beetle damage may occur on suspended fruit it is usually most common on the undersides and ends of fruits on or near the ground.

Bird damage resembling this caused by linnets in Essex has also been seen on a few strawberry fruits on holdings in the Wisbech area. It is quite possible, however, that other seed-eating birds may cause such damage in other areas.

E. B. BROWN

Leek Moth occurring Inland. The leek moth, *Acrolepia assectella* Zell., is well known on the Continent as a pest of garlic, leeks, onions and shallots. It was first reported in England in 1943 and since then its attacks have been confined to a narrow coastal belt of east and south-east England (Jary, Rolfe and Carpenter, *Agriculture*, 1948, **54**, 563-9). However, in late August 1959, the pest appeared on leeks in the Royal Horticultural Society's Vegetable Trial Grounds at Wisley, and attacked about 80 per cent of the plants, many of them being severely damaged. Mr. A. G. Pannell of the Murphy Chemical Co. also reported similar infestations in Hertfordshire, at Redbourn and Wheathampstead, during the same month.

As far as is known this is the first occasion on which the leek moth has been reported so far inland in Britain and it was thought that this may have been due to the unusually warm summer of 1959. However, it was recently discovered that the pest has been infesting a seedsman's nursery in Cobham for at least three years. Further attacks on leeks occurred at Wisley in mid-July 1960, and, in an adjacent plot, onions which were lying on the soil to dry were also tunnelled by the caterpillars. Further investigation has revealed that slight attacks have occurred on nearby commercial holdings.

In 1959 it appeared that good control was obtained at Wisley by the application of DDT emulsion at the rate normally recommended for caterpillars (approx. 0·06 per cent active ingredient). In 1960, however, four applications were given without completely eradicating the pest, which continued to cause damage until mid-October.

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